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Northeastern Forest
Experiment Station

ANNUAL REPORT 1963

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NORTHEASTERN FOREST EXPERIMENT STATION • Ralph W. Marquis, Director

INTRODUCTION

WRITING a report on research progress every year is something like writing home from college every week. Nothing much seems to have happened in that short time; so you usually end up by asking for more money.

But if you look back over a semester in college, or over a 5-year period in research, the little incidents that hardly seemed worth reporting individually often add up to something quite significant. And the reported incidents, all put together, form patterns of changing direction and emphasis, and some real accomplishment:

- More money did come from home. Allotments for research for fiscal year 1964 were 70 percent above those for 1959.
- Two research centers, at Beltsville, Md., and Paul Smiths, N. Y., were closed; and personnel were transferred to other locations. Three experimental forests were closed. The purposes were to reduce costs, to form larger and more effective research teams at field units, to drop some relatively unproductive studies, and to locate studies and personnel in a scientific environment.
- Field units have been established at three new locations: genetics at Durham, N. H.; watershed and recreation at Syracuse, N. Y.; and marketing at Princeton, W. Va. Field headquarters in the Allegheny area were moved from Kane to Warren, Pa.
- A Station library has been formed and staffed, to serve the headquarters and field offices of the Experiment Station and the Regional Office.
- A biometrics unit has been established at New Haven to provide statistical service to all projects and to further the use of electronic computers in all data processing.
- The Station printing plant has been largely abandoned. Station papers and miscellaneous publications are now being produced by commercial printers. During the past 5 years more than 500 publications authored by Station personnel have been issued or published in scientific and trade journals.
- Funds were made available for the construction of five new laboratories. Two of these, at West Thornton, N. H. (watershed research) and at Princeton, W. Va. (forest products marketing research) have been completed and are now occupied.

The Forest Recreation and Wildlife Laboratory at Warren, Pa.; the Timber and Watershed Laboratory at Parsons, W. Va.; and the Methods Testing Plant at Princeton, W. Va. are under construction and scheduled for completion by mid-summer.

- Space at other field locations has been upgraded by moving into new quarters (Burlington, Vt., and Orono, Me.) or by renovation, remodeling, or repair of existing quarters. New field laboratory facilities have been established and equipped at Orono and Burlington, and improvements have been made in the laboratories at New Haven, Laconia, Alfred, and New Lisbon. The headquarters staff in Upper Darby still lives in hope, and is encouraged by the recent acquisition of a 7-acre tract of land in Radnor (10 miles from the present office) to be the site for a new office building, some day, for Region 7 and the Station.
- A number of new fields of research have been entered during the past 5 years. These include recreation, wildlife habitat, forest products marketing, eastern softwood log and tree grades, management of municipal watersheds, and economics of government forestry programs. The responsibility for forest pest detection and appraisal surveys was transferred from research to the Regional Office.
- The organization of the research program has been revised. The research center, which was fundamentally area-oriented and which placed technical responsibility in many disciplines on the center leader, has been replaced by the new project form of organization. The projects are problem-oriented, and each is headed by a research scientist competent in his specialized field. Division Chiefs have been delegated line authority over the technical aspects of the projects under their supervision. This new organization provides closer association of scientists in any discipline, economy in the use of common laboratory facilities, and an opportunity for greater depth in research.
- The change-over to the project form of organization has called for the preparation of new line-project statements; and this in turn has required a re-evaluation of problems to be studied, new emphasis on certain studies, and a better understanding of the proper balance between basic and applied research. The first results of this reappraisal will appear in the following chapters of this report.
- The Station continues to be a training center for scientists, as it well should be in view of the excellent opportunities for

advanced study afforded by the universities in the Northeast. The Station has taken advantage of recently enacted legislation which, under prescribed conditions, permits the use of federal funds for training employees in outside institutions. Ten employees have been given full-time (1 year) assistance; 33 others have received such training for lesser periods of time.

- If scholastic attainment is taken as a criterion of scientific capability (it is by no means the only one), the Station ranks high and is improving. Sixty-four of our 100 professional employees hold academic degrees higher than the baccalaureate. Five years ago there were 17 employees of the Station who held Ph.D. degrees. In the following 5 years eight men with their doctorates left the Station—five of them to accept teaching positions in forestry schools. But even with this contribution to the educational profession, the Station now has 25 employees with the Ph.D. degree. And 10 more are in various stages of receiving the degree, most of them working on dissertation problems.

Progress in our individual research studies for 1963 and, in some cases, for a longer period, is reported in the following pages.

TIMBER MANAGEMENT

AS USUAL it is not possible, in this report, to describe all of the progress made and results achieved during the year, but we will attempt to include the most important items—with special attention to silvicultural systems, direct seeding, the spruce-fir project, and other silvicultural research. But first, a few special happenings are worth a brief mention here:

- The name of the Division of Forest Management Research was changed to *Timber* Management Research to more properly represent the true function of the Division.
- Ashbel F. Hough retired on December 7 after nearly 42 years of service, mostly on silviculture research of Allegheny hardwoods. We are going to miss our expert on black cherry and other associated species.
- In April, the silviculture project on spruce-fir moved its head-

quarters from Brewer, Maine, to a new USDA building on the campus of the University of Maine at Orono.

- And in September the genetics project moved its headquarters from Chestnut Hill, Pa., to a new location on the campus of the University of New Hampshire at Durham.
- Construction is well under way on new office-laboratories at Parsons, W. Va. (Timber and Water Laboratory) and at Warren, Pa. (Forest Recreation and Wildlife Laboratory). Personnel at these two locations expect to move into the new buildings early next summer.

SILVICULTURAL SYSTEMS

This has been a year in which the applied research needs of the forest manager have been given renewed thought, in regard to the adequateness of current information. We have especially considered the status of current silvicultural systems in the light of the increasing interest in and apparent need for even-aged systems in northeastern hardwoods by the larger private and public forest land holders.

Most foresters in applied research tend to have interests (and research programs) that are tied closely to the needs of the time, even though these needs may be short-lived. This is the popular thing to do; but what this often means is that the researcher does not begin to work on a problem until after the answers are needed. And if getting the answers requires several years' work — as it often does — this further complicates the situation.

Somehow we need to be able to look ahead, accurately assess the needs, and have the answers at hand before the needs arise. This is not easy to do, and some estimates of need may be in error. Also it is difficult for researchers to "stick their necks out" like this in the day-to-day presence of their colleagues in practicing forestry who are apt to take a dim view of anything in research unless they can see a current use for it.

As a case in point, take the subject of silvicultural systems in the management of northeastern hardwoods. Fifteen years ago, it was bad policy in forestry to talk about anything except some form of a selection system; and researchers, in keeping with the times, initiated studies (many of a long-term nature) on problems associated with selection systems. However, to the credit of some, even then some small studies of even-aged systems were squeezed into the programs, though mostly inadequate in scope and depth. Today the worm has turned, and the pressure

is almost suddenly great for some form of even-aged silviculture, especially on large land ownerships.

The main reasons for this switch are a greater interest in the more valuable intolerant species such as yellow birch, paper birch, black cherry, white ash, and yellow-poplar; a need to simplify silviculture and logging; and a desire to make accountability of treated stands more feasible for management. By simplicity and accountability it is meant that, instead of trying to keep track of all of the little patches or group-selection openings, the effort would be to treat larger areas in the same way and at the same time—including cultural treatments and intermediate cuttings as well as harvest or regeneration cuts.

However, it is one thing to recognize the needs and another thing to decide whether or not to drop research on all other systems and work only on even-aged systems—the new trend. This could be a mistake because we feel that there always are many forest managers and owners who wish to apply some form of selection (single tree or group). This is especially true on small ownerships, where to apply an even-aged system uniformly over the entire forest would mean long periods of no products to cut or sell, and possibly a loss of interest in forestry during the interim. Also, even some of the large owners will have certain forest conditions or other reasons for favoring a selection system. This is their decision to make.

Therefore, instead of completely succumbing to pressure for even-aged silviculture, we plan to continue research on other types of silvicultural systems. We need to find the answers to an array of possible methods of management and to be able to advise or recommend under what conditions and circumstances they are most applicable. In the final analysis, the system adopted by the landowner should be the one that proves most profitable for timber-growing, although his choice of a system will have to be considered in the light of feasibility, the species desired, age of stand, site quality, product objectives, size of ownership, other uses (multiple use), and other factors.

Certainly it is important that we give even-aged silviculture a higher priority than we have given it in the past, and in some instances higher priority than the older selection systems that we have had more time to learn about. We have excellent research in progress on patch cuttings, and we are getting our second wind on seed-tree and strip cuttings. This is good, but there is urgent need to explore more thoroughly the shelterwood systems, which give us the benefits of a desirable seed source, partial shade for new seedlings, and some degree of shade

control of undesirable sprout and shrub competition. We have silvicides to help control any sprout and shrub growth that cannot be controlled naturally.

The shelterwood method has at least two other virtues that may prove desirable in northeastern hardwoods. First, it can be applied to areas of any size where stand and ground conditions permit uniform treatment. Second, it should work well not only with intolerant species, but also perhaps nearly as well with some tolerant species.

The above case on silvicultural systems is cited as an example of one of our most prominent problems in research programs—to keep ahead of forestry needs, but to avoid ephemeral research trends.

DIRECT SEEDING

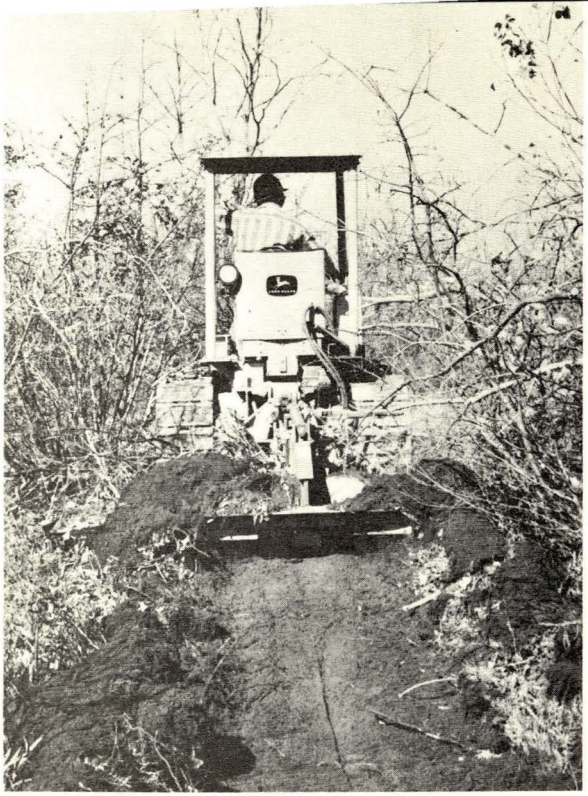
Direct seeding of forest trees—as opposed to planting nursery-grown seedlings—has been tried many times and in many places in this country since the early 1900's; but until the last decade, successes were few and far between. One of the primary causes of failure has been consumption of the seed by birds and small rodents.

About 10 years ago, through cooperative attack by the Fish and Wildlife Service and the Forest Service, a real break-through was achieved in the search for an effective practical treatment for protecting seed from wildlife. The key ingredients in the treatment are two commercial products known as Arasan and Endrin; the seeds are coated with these materials combined with a latex sticker. The Alexandria, La., research unit of the Southern Forest Experiment Station was an early cooperator with the Fish and Wildlife Service, and has continued to be the major center of direct-seeding research in the East. Industrial land holders in the deep South promptly began applying the Alexandria research findings, and in that region thousands of acres are now being seeded to pines each year. Somewhat parallel research was conducted in the Pacific Northwest; and there also industry is now successfully applying the results on a large scale.

In the Northeast, no direct-seeding research worthy of the name was done during the 1950's, except in the Pine Barren region of New Jersey—and that work did not involve the new seed protectants. Those of us in research who had observed the successful seedings in the South recognized that the southern methodology could not be lifted intact and applied with equal success in the Northeast, for several reasons:

Example of a moderately steep and stony direct-seeding site in West Virginia, just after logging. This area will next be treated with herbicide and then seeded to white pine by helicopter. The objective is to convert the low-site hardwoods to pine or pine-hardwoods.

- Our conifers, such as red and white pines and the spruces, start much more slowly than the southern pines. They require 5 years or more to attain the height reached by loblolly and slash pines in 2 years.
- Our conifers have smaller seeds, and consequently tend to be more delicate and more susceptible to adverse conditions during the germination and initial establishment period than the southern pines.
- Our weather conditions during and immediately after the crucial germination period often are not favorable for initial seedling establishment.
- Our brushland and cut-over sites commonly have surface organic layers—in some places 4 or 5 inches thick. These are relatively unfavorable seedbeds.
- Many of our potential seeding sites are stony—often both stony and steeply sloping.



MAINE FOREST SERVICE PHOTO
Site preparation for direct seeding in a brushland type in Maine. The plow and tractor are standard equipment for fire-line construction.

All of this means that our site preparation has to be more intensive and that the seeds usually have to be covered to provide reasonable chances for success. But on many of our steep or stony sites, good preparation by mechanical means is difficult or impossible. And without adequate site preparation, early weeding or release treatments often will be required to get our slow-starting species through the herb and brush competition.

Because of these conditions and circumstances, we in the Northeast did not immediately embark on a direct-seeding program after the break-through in seed protection. Problems in site preparation remained to be solved—problems that defied easy solution.

However, the Station is now moving into direct-seeding research as fast as other commitments and available funds and manpower will permit. This has been going on in a small way for several years. The emphasis on direct seeding in several project programs is being increased. Seeding investigations are under way at five projects: New Lisbon, N. J.; Warren, Pa.; Burlington, Vt.; Elkins, W. Va.; and Alfred, Me.

New Lisbon Project

This project has the longest record of seeding investigations: tests have been conducted here intermittently for more than 20 years. Possibilities for successful spot-seeding of Atlantic white-cedar were demonstrated in the 1940's. During the same period, spot-seedings of shortleaf pine were tried, but these failed because of rodent depredations and sowing too late in the spring.

More recently (1955-61), a method for direct-seeding pitch and shortleaf pines on the sandy soils of southern New Jersey was developed that is fairly reliable on suitable seedbeds in years of normally distributed rainfall. Seedbeds are prepared by burning to reduce the litter of the forest floor; untreated seed are broadcast in January or February; then the area is gone over with a brush hog (rotary brush cutter), which chops up brush and debris and thus lightly covers the seed.

Current seeding work in this project is centered in the scrub-oak vegetation type in the Pennsylvania Pocono region. The soils here are too stony to prepare mechanically, and the basic methodology therefore consists of reducing the brush with herbicides, and breaking up the thick organic mat to expose mineral soil by use of a root-rake stripped down to three teeth.

Red and jack pines are the major species under test. Present indications are that seed treatment is necessary here, that mineral soil is superior to the natural humus as a seedbed, and that seed coverage is important but must be thin—coverage of ½ inch or more markedly reduces germination. Relatively heavy mistblower herbicide applications—8 pounds acid equivalent of 2,4,5-T per acre—are required for adequate control of the brushy vegetation.

Warren Project

Direct-seeding studies at Warren are concerned primarily with black cherry. White ash will be included in future tests. The seeding work here dates from 1960. It involves both open-field sites and recently cut-over land.

An important facet of the work with black cherry is seed handling—how to store seed and treat it for prompt, complete germination after sowing. The essential requirements are to keep the seed moist through all handling steps, and to stratify it several months in a moist — not wet — medium at temperatures just above freezing. The use of fully ripened, depulped seed is recommended.

In small-plot seeding tests with black cherry on variously pre-

pared seedbeds on an open site, germination was generally adequate where the seed was covered or pressed into the soil; but growth was severely inhibited by the grassy vegetation, even where it was kept short by clipping. On the other hand, in recent clear-cuttings where the herbaceous vegetation was sparse, first-year growth of cherry seedlings on various seedbeds averaged 10 to 17 inches—much better than in the old field.

The study on the clear-cuttings included exclosures of several types to evaluate wildlife pressures, but seed depredation on exposed plots was sporadic and relatively light. Overall germination averaged 57 percent. Again it was observed that the seed must be covered, or at least embedded firmly in the soil, for good germination.

Burlington Project

Seeding research at this project is limited to several informal studies, dating from 1957, at the Hopkins Experimental Forest in Massachusetts. One of the studies involved spot-seeding of balsam fir and Norway spruce. Germination was poor, and little came out of the study except a demonstration of rodents' preference for spruce seed, as compared to fir seed.

All the other studies deal with sugar maple. The main variables in the tests were protection from rodents, mulch materials, and light intensity. The importance of the rodent factor remains uncertain: one fall seeding germinated better where protected, but a spring seeding germinated equally well with and without protection. Sawdust and hardwood leaf mulches depressed germination, as compared to no mulch; vermiculite mulch substantially increased germination. Sawdust also depressed growth of seedlings that did emerge. Maple seedlings survived and grew better under 33 to 67 percent shade than in the open. Present plans anticipate more intensive seeding research with sugar maple in the next few years.

Elkins Project

Elkins has only one direct-seeding study, and it is only beginning. It is a conversion study in low-site hardwoods, conducted in cooperation with the Monongahela National Forest. Four treatments have been applied to replicated 8-acre plots as follows: (1) logging only; (2) logging followed by aerial spraying with herbicide; (3) same herbicide treatment with no logging; and (4) no logging or spraying. Stratified Arasan-Endrin-treated

white pine seed, at the rate of 10,000 viable seeds per acre, will be broadcast from a helicopter on all plots in the spring of 1964.

Alfred Project

More effort is going into direct-seeding at Alfred than at any of our other projects; this effort amounts to almost full time for one professional man, plus assistants. Major emphasis is on white pine and red pine. Seeding research here may be dated back to a large-scale aerial seeding test after the disastrous forest fire of 1947. This seeding generally failed. Small plot tests, designed to evaluate some of the soil and microsite factors, were started in 1958. The seeding research was intensified in 1962-63, but much of the work still is exploratory and preliminary. The current studies deal with seed handling, seeding rates, frost-heaving in relation to soil types and shading, and methods for mechanical site preparation.

Tests of varying stratification periods and temperatures for white pine seed have indicated 60 days at 40° F. to be about optimum for prompt, complete germination. In tests of the several components of the Arasan-Endrin seed treatment on white pine seed, both Arasan and Endrin slowed the rate of germination, and Arasan also reduced total germination about 10 percent.

Pine seedlings grown under partial shade suffered less frost heaving than seedlings grown in the open, apparently for two reasons: (1) better root development; and (2) longer hypocotyls, which tend to permit more lifting of the soil surface without decapitating the seedling. Contrary to usual expectations, more frost-heaving mortality occurred on an exessively drained loamy sand than on a loamy soil.

Preliminary tests of site preparation by furrowing with a fire-line plow have been done, and a more comprehensive formal study is planned. On relatively level brushlands with stone-free soil, the fire-line plow does an excellent job. At 8-foot spacing, such furrowing can be done for about $10 per acre.

It has been observed on several occasions that the Arasan-Endrin treatment does not fully protect seed from rodents in small experimental sowings. In larger sowings, the rodent pressure presumably would be more diffused over the area, and seed destruction would be proportionately less.

Plans for future work at Alfred include experimentation in the following fields: (1) seed treatment formulations for better protection; (2) site preparation methods for stony as well as stone-free soils; (3) seed germination and establishment require-

ments, leading to criteria for classifying sites according to the need for site preparation and the kind of site treatment required; and (4) seeding in understories.

THE SPRUCE-FIR PROGRAM

Our silvicultural research in the spruce-fir region began with sample-plot studies on private holdings in 1923. It received more attention in the early 1930's with the establishment of the Gale River Experimental Forest on the White Mountain National Forest in New Hampshire. But two disastrous hurricanes in 1938 and 1950 damaged the timber stands at Gale River so severely that the research program there had to be abandoned. Large-scale partial cutting experiments to test silvicultural control of the spruce budworm were established on private holdings in cooperation with the timber industry from 1945 to 1948.

Since 1950 much of the research work has been conducted on the Penobscot Experimental Forest, a 4,000-acre tract near Bangor, Maine, that was purchased by nine Maine timberland owners and made available to the Station for research under a long-term lease. At that time the Station established a research center at Bangor. The headquarters for this unit, now designated as a project instead of a center, were recently moved to the campus of the University of Maine at Orono.

The Spruce Budworm Cuttings

This is the oldest study in the project that is still active. Starting in 1945, cuttings to remove a large proportion of the merchantable-size balsam fir were made in both softwood and mixed-wood types on industrial forest land at six locations in the region. Since fir is the preferred host of the budworm, the theory behind the test was that removing much of the fir would curtail budworm build-ups in the stands and thus would prevent excessive damage. However, the budworm has not developed in epidemic numbers in the section of Maine where the experimental cuttings were made, so this silvicultural control measure has not been put to a rigorous test. The cutting areas have therefore been maintained for study of the effects of partial cuttings.

Average annual net growth in the softwood types at the six locations has ranged from 0.53 to 1.08 cords per acre. In the mixed-wood types it has ranged from -0.28 to 0.57 cords per

acre. Hardwoods and balsam fir made up most of the mortality.

Although many of the hardwoods were overmature and defective, they were not cut in the original treatments for budworm control. One of the main lessons demonstrated on these cuttings is that the hardwoods contribute but little to net growth: most of the growth comes from the softwoods. Hardwood mortality may almost equal, or even exceed, gross growth. Obviously removal of the defective hardwood component should be one of the first steps in placing mixed-wood stands under management.

The Compartment Experiments

The largest single study in the project is the so-called compartment study, started in 1951 on the Penobscot Forest. The purpose is to determine the long-term cumulative effects of different methods and intensities of timber management on gross and net returns per acre and on volume yields per acre. It involves 28 compartments totaling about 900 acres. The treatments include two silvicultural systems—selection and shelterwood; six management programs—intensive selection, selection, diameter limit, 3-cut shelterwood, 2-cut shelterwood, and commercial clear-cutting; four cutting cycles—5, 10, 20, and 30 years; and two product objectives — pulpwood only, and integrated products.

Average annual growth and mortality per acre during the 8 to 12 years since the first cuttings, as calculated from sample-plot inventories, are shown below for five compartments representing four of the management programs and an uncut area:

Compartment No.	*Management program*	*Initial volume*	*Gross growth*	*Mortality*	*Net growth*
		—(rough 85-cubic-foot cords)—			
32	Natural area—no cutting	26.42	0.89	0.52	0.37
8	Commercial clearcut	8.60	.59	.22	.37
11	Diameter limit	18.78	.69	.07	.62
9	Intensive selection	18.28	.74	.10	.64
23	Shelterwood	15.64	.94	.18	.76

Two compartments on the experimental forest are used as small woodlot demonstration areas. By frequent light selection cuttings and stand-improvement work, the poorer trees have gradually been removed and the better trees have been given more growing space. Net growth has been 0.60 cord per acre per year on one woodlot and 0.51 cord on the other. Average

annual returns from the cuttings for stumpage and labor have been $5.72 and $8.86 per acre. Returns per man-hour have averaged $1.15 and $1.22.

Cooperative Growth Studies

Average growth rates by forest stand classes in the spruce-fir region have been obtained from more than 1,000 plots in a study conducted in cooperation with 11 industrial forest landowners. Data for the first 5 years have been summarized and published. The study probably will be terminated when 10-year measurements have been completed and reported.

In general, growth was found to be considerably better than had commonly been supposed—certainly better than the 1/10 cord per acre per year that was sometimes used as a regional average. And a few of the best stands are capable of growing up to a cord per acre per year. The publication gives instructions for estimating the annual growth on any given forest property, provided the acreage in each of the different stand classes is known.

The same permanent sample plots are being used for another cooperative study—an investigation of growth in relation to soil-site factors. Topographic and soil information is being taken on the plots; this and the stand information from the original study will be used in an attempt to develop growth-prediction equations. Besides the timberland owners, the Soil Conservation Service and the Maine Agricultural Experiment Station are cooperating with the Northeastern Station in this work.

Cooperative Wood-Density Study

Another extensive cooperative undertaking, based in part on the same growth plots, is a study of wood density of the principal softwood species of Maine. The cooperators with the Station are the Maine Agricultural Experiment Station, the U. S. Forest Products Laboratory at Madison, Wis., and 18 industrial timberland owners. The study is designed to determine various specific-gravity relationships of the wood within trees and among trees of different sizes and ages growing under different conditions. A supplemental objective is to find trees that are superior in density, as well as in form and growth characteristics, for possible use in breeding and other tree-improvement research. Several thousand trees have been sampled, and the study is nearing completion.

Red Spruce Site Studies

A method for determining site quality in mature, mixed uneven-aged stands of red spruce was developed and published in 1957. More than 900 carefully selected trees in 32 stands were measured for height and diameter, and from these data a family of site-index curves was prepared. These resemble conventional site-index curves except that they are based on height over diameter rather than height over age. To determine site index of a stand, height and diameter of a sample of dominant red spruce trees are measured and averaged. From these averages site index can be read from the curves. For a somewhat more precise determination, site index can be calculated from mathematical formulae.

A site classification based on soil and topographic features also was developed. This is particularly useful where no red spruces suitable for measurement as sample trees are growing on the site. Five site classes were described according to various combinations on soil depth, soil texture, and topographic position.

Regeneration Studies

Research in regeneration has dealt with seed consumption by wildlife, with seedbed requirements of both conifers and paper birch, and with site preparation for planting paper birch.

Exposure of seed in feeding trays in the wild showed that mice and voles take spruce seed in preference to fir seed in a ratio of about 70 to 1. A study is now under way to determine the effects of seed consumption by small rodents and birds on the natural regeneration of spruce and fir. The study involves estimates of natural seedfall and of rodent and bird populations, and observations of germination and tree seedling survival in plots to which access by wildlife is variously controlled by means of exclosures. From this study we hope to get useful information about the impact of seed-eating wildlife on spruce regeneration in particular.

A recent study of seedbed treatments under dense softwood stands showed much greater catches of spruce and hemlock seedlings where the humus layer was either removed or mixed with the mineral soil than where it was burned or left undisturbed. Hardwood leaf litter was detrimental to seedling survival. The practical implications from these findings are: log when the ground is bare and not frozen, so as to break up the humus

layer; log during good seed years insofar as practicable; and remove hardwoods to minimize accumulations of hardwood leaf litter on newly germinated softwood seedlings.

In a study of effects of different seedbeds on paper birch regeneration after clear-cuttings, both disking and burning after logging resulted in substantially better seedling establishment than either summer or winter logging without further treatment. However, the seedbed treatments also favored aspen, and early weeding may be required to release the paper birch.

Three-year data from seed traps operated in connection with the above study revealed large differences among years in amount of paper birch seedfall, time of dispersal, and seed viability, as shown in the following tabulation.

	1958-59		*1959-60*		*1960-61*	
Month	*Seed dispersed*	*Viable*	*Seed dispersed*	*Viable*	*Seed dispersed*	*Viable*
	%	%	%	%	%	%
August	6	0	58	22	51	75
September	13	1	25	20	13	78
October	63	11	13	41	20	74
November	14	24	3	32	14	80
Dec.-May	4	34	1	18	2	79
Total	100	13	100	24	100	77
Est. No./acre (millions)	1.3	—	0.8	—	16.8	—

Paper birch planting tests have been conducted on seven old-field areas. The site preparation was variations of plowed furrows and hand scalping. Highest survival and best growth were obtained on the overturned slice of a double furrow; here about two-thirds of the seedlings were still alive after 4 years. The poorest results occurred where seedlings were planted in the sod with no preparation. Plantings in furrow bottoms and in scalps ranked intermediate.

Miscellaneous Small Studies

Several small studies concerned with pruning red and white spruces, thinning balsam fir thickets, thinning white spruce, the damage done by the balsam woolly aphid, the efficacy of different sizes of seed traps, phenology of red spruce and associated species, and a demonstration of different management intensities are in progress or have recently been completed. Space permits additional comment on only one of these studies:

The balsam woolly aphid apparently is causing more than half (54 percent) of the fir mortality on the Penobscot Experimental Forest, according to observations dating from 1954. In 1959, as a trial of biological control, more than 15,000 of the imported predaceous beetle, *Laricobius erichsonii,* were liberated in two compartments where the aphid was abundant. Subsequent observations indicate that the beetle has become established, but it is still too soon to evaluate the effect on aphid populations.

OTHER SILVICULTURAL RESEARCH

Sweetgum Seed Production

In the natural regeneration of a cutover area, the foremost requirement is an adequate supply of viable seed. During the past year, new information on the production and distribution of sweetgum seed was obtained at the silvicultural project at New Lisbon, N. J. Contrary to some earlier beliefs, the number of fully developed seeds per fruit appeared to be relatively high. Fruit collected in 1962 contained an average of 88 seeds apiece; and 84 percent of these seeds were sound. Seedfall began about September 20 and continued into the spring, but 99 percent of the seedfall was completed by mid-January. Seedfall reached its monthly peak in November when 75 percent of the total seed catch occurred.

In the open areas adjacent to four sweetgum stands, the seedfall per unit area decreased rapidly with distance from the seed source. The seed catch under the source varied among stands from 372,000 to 6,184,000 sound seeds per acre. At a distance equal to stand height, the seed catch was 43 percent or less of that under the source; at a distance of four times stand height, 5 percent or less. Although occasional sweetgum seeds are transported to great distances, the width of clear-cut areas apparently should not exceed four times the height of the dominant bordering trees if ample seed for prompt regeneration is to be provided. A possible alternative would be to leave about four or more seed trees per acre, and then remove these trees as soon as adequate reproduction has started.

Sugar Maple Seed Storage

Many species of forest trees produce good crops of seed only at infrequent intervals. Thus, for nursery and direct-seeding purposes, it would be helpful to have methods for storing the seeds

In some years, sweetgum produces seed prolifically, as evidenced by the many fruits on these trees. In 1962 the catch under such stands was up to 6 million sound seeds per acre.

of these species for several years without appreciable loss of viability.

Within the seeding and planting project at Burlington, Vt., a study is under way to determine the viability of sugar maple seed stored at four seed-moisture contents in combination with four temperatures. Results after storage over one winter already reveal that moisture content and temperature influence germination percentage. At a storage temperature of 65°F., germination increased from 0 to more than 94 percent as seed-moisture content decreased from 35 to 10 percent; at lower temperatures, the apparent effects of moisture content upon germination percentage were much less pronounced:

Seed moisture content (%)	*Storage temperature*			
	+65°F. (%)	*+45°F. (%)*	*+35°F. (%)*	*−15°F. (%)*
35	0.0	89.6	94.6	94.7
25	16.1	97.0	97.3	94.8
17	40.6	97.2	98.5	97.9
10	94.8	94.1	96.7	96.7

Vegetative Propagation of Sugar Maple

Vegetative propagation is an important and necessary tool for studying the inheritance in sugar maple of various tree characteristics such as sap yield, sugar concentration of the sap, timber growth and quality, and flowering habit. To develop suitable methods of propagation, various techniques for rooting and over-wintering sugar maple cuttings are being studied at the Burlington tree-improvement project.

Root development on greenwood cuttings of sugar maple generally requires about 8 to 12 weeks. Rooted cuttings examined after this period may be divided into those with relatively long, branched roots (type 1) and those with short, unbranched roots (type 2). One significant finding to date has been that survival depends to a great extent upon the type of root system possessed by the cutting. Rooted cuttings must undergo a hardening-off period before being stored over winter. In one experiment, 18 percent of 300 cuttings with type-1 roots died during the hardening-off period as compared with 38 percent of 400 cuttings with type-2 roots.

Most dormant rooted sugar maple cuttings must be chilled for at least 42 days before they will be able to break dormancy and resume growth. The importance of well-developed roots is further exemplified in the following tabulation of the results

of an experiment on the survival of rooted sugar maple cuttings following chilling at different temperatures:

Chilling temperature (°F.)	Type-1 roots		Type-2 roots	
	Sample size (No.)	Survival (%)	Sample size (No.)	Survival (%)
28	685	5.80	113	0.88
33	685	9.05	113	.88
38	94	3.19	43	.00

Shortleaf Pine Seed Sources

As part of a region-wide study of southern pine seed sources, seven geographic sources of shortleaf pine are being compared by project personnel at New Lisbon. To date, a native source clearly exhibits the best survival and growth.

Five years after planting, 94 percent of these New Jersey stems were still alive, and their average height was 6.8 feet. The Tennessee and Missouri sources were second best, with survivals of 70 and 72 percent, respectively, and average heights of 5.4 and 5.2 feet. Next in order were the Virginia and South Carolina sources, followed by the ones from Georgia and Louisiana. Although the Louisiana source had the poorest survival, 23 percent, the Georgia source averaged the shortest, 3.4 feet, which is only half as tall as the native New Jersey source.

Selecting Superior Sugar Maples

During the past 2 years, a survey of sugar bushes has been in progress in Maine, New Hampshire, Vermont, and New York to determine the variation in sugar content of maple sap and to select phenotypes for high sugar production. The survey is a cooperative venture of the Northeastern Station's tree-improvement project at Burlington and the Northeastern Forest Tree Improvement Conference.

A survey technique was recently developed that has several advantages over previous methods in that it: (1) is easy to apply, making no use of complicated selection criteria; (2) permits rapid coverage of a large area; (3) makes allowance for localized differences in stand conditions; (4) minimizes environmental effects; and (5) provides for both the initial screening of possible plus trees as well as the retesting of these trees to provide a strong basis for final selections.

Under this survey method, the field man follows a cruise line along a contour through a given sugar bush and samples the

sugar contents of individual trees. If a noticeably high sugar content is encountered, the field man takes readings on four or five comparable trees — called standards — adjacent to this sweet tree. To be selected as a possible plus tree, the sugar content of the sweet tree must: (1) exceed the sugar content of the sweetest standard by an absolute value of 0.5 percent, and (2) be proportionately higher than the average of all adjacent standards by at least 30 percent. The selected trees and their surrounding standards are marked so that they can be located and tested twice more during the current sugaring season and twice again the following season. At the time of the last reading, a final screening and selection of the most promising candidates is planned. Using this survey method, two men can take a 100-tree sample in less than 2 hours without the need of professional supervision.

A summary of the progress to date on the four-state survey, including the numbers of initial selections, is given in the following tabulation:

State	*Sugar bushes surveyed (No.)*	*Trees tested (No.)*	*Selected phenotypes (No.)*
New Hampshire	5	399	12
Vermont	37	2,400	59[1]
Maine	5	198	8
New York	13	338	7
	60	3,335	86

[1]Includes 2 trees selected for unusually low sugar content.

Birch Hybrid Performance

The Station's pedigreed birch progenies, planted near State College, Pa., in 1946, were remeasured in 1962. These trees were 22 to 24 years old from seed at the time of measurement. Although analysis of the data has not been completed, several items of general interest have come to light. For example, selfed progenies show no significant reduction in growth as a result of self-fertilization. And the following interspecific hybrids have been confirmed by morphological and cytological studies: *Betula populifolia* (gray birch) x *B. papyrifera* (paper birch); *B. lenta* (black birch) x *B. alleghaniensis* (yellow birch); and *B. papyrifera* x *B. alleghaniensis*. None of these hybrids shows any evidence of hybrid vigor; but all of the hybrids appear fertile, and the percentage of good pollen is high.

Backflash in Sweetgum

In late April 1962, injector treatments with 80 pounds acid equivalent (per 100 gallons) of a 2,4,5-T ester were used in thinning a 14-year-old sweetgum stand in southern New Jersey; and much to our surprise, damage to the crop trees developed. A year after treatment, 17 to 23 percent of the selected crop trees showed crown injury, but many recovered during the 1963 growing season. On the basis of crown condition in late summer, the ultimate mortality of crop trees will be low, probably 3 to 6 percent—most of which has already occurred.

Root grafts were the apparent mode for the observed backflash. And spacing between the crop trees and treated trees greatly affected the amount of damage. A damaged crop tree was, on the average, only 9 inches away from the nearest injected tree; and the maximum distance between a damaged crop tree and an injected stem was 16 inches. In contrast, the average distance between an unaffected crop tree and the nearest injected stem was 20 inches.

Despite the occurrence of root grafts, injector thinnings in sweetgum stands still seem feasible provided that certain pre-

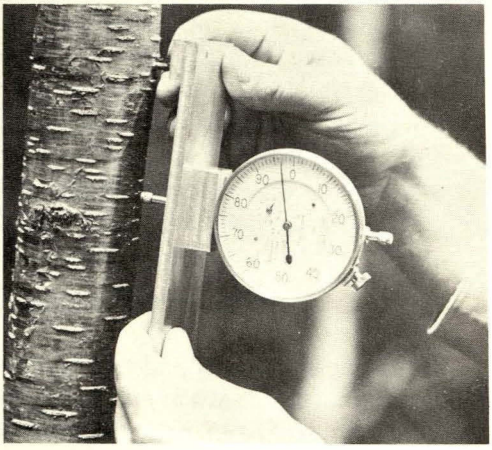
A root graft between two 14-year-old sweetgums. The stem on the right was injected with 2,4,5-T, and both stems died within a year.

cautions are observed: (1) limit the treatments to stems at least 1½ feet away from desired crop trees, and cut or girdle closer unwanted stems; or (2) limit injector treatments to months other than those from April through July—the months when backflash damage is most likely to be serious.

Pruning Yellow Birch

At Laconia, N. H., exploratory work is under way on the seasonal radial growth of yellow birch saplings pruned during spring to 50, 65, and 75 percent of total height, with untreated control trees for comparison. The results to date indicate that average rates of growth for the various treatments recover quickly after an initial setback in spring after the pruning. However, total seasonal growth tends to be consistently lower with increased pruning intensity.

Radial growth measurements on trees of sapling size are being facilitated by a new mounting platform that has been developed at Laconia for use with a dial-gage dendrometer. This platform utilizes two reference points anchored in the xylem instead of the usual three, thereby facilitating the use of the dial-gauge dendrometer on small trees. Measurements with the two-point platform appear to be somewhat more variable than those taken on trees of suitable size with the three-point platform, but seasonal differences between the two methods are not significant. And further efforts are being made to improve the accuracy of the two-point method.



A close-up of the two-point mounting platform for a dial-gage dendrometer. The upper reference point can be seen near the man's right hand; the lower reference point is obscured by his left hand.

FUEL-MOISTURE STUDIES

TWO fuel-moisture studies were conducted in New Jersey in 1963. One was designed to correlate the measured litter and duff moisture in a hard pine stand and a hardwood (oak) stand with fine fuel moisture, build-up index, and adjusted fuel moisture as obtained from tables 1 to 5 of the Preliminary National Fire Danger Rating System. The second study was designed to show the relationship of the measured moisture content of lesser vegetation to fine fuel moisture during the cured stage and to build-up index during what would normally be the green stage.

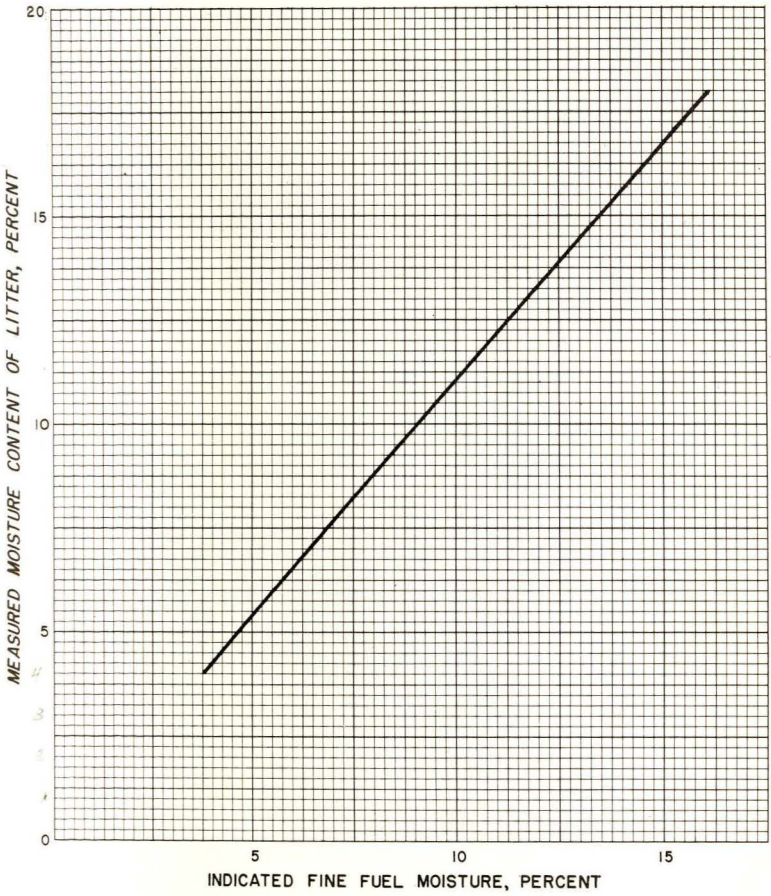
Data from these studies are now being summarized and analyzed. Preliminary analysis indicates that there is reasonably good correlation between the measured moisture content of the surface layer of needle litter in a loblolly pine stand and the fine fuel moisture data from the Preliminary National Fire Danger Rating System. There is also good correlation of moisture content as measured in the surface litter of an oak stand during the cured herbaceous stage, and fine fuel moisture as derived from table 1 of the Preliminary National Fire Danger Rating System. For some unexplained reason, similar correlations at the green and transition herbaceous stages in oak stands are quite low.

THE 1963 FIRE SEASON

Weather conditions and the resultant fires of 1963 emphasized the fact that much work remains to be done in the various fields of fire control, from prevention to suppression. Great numbers of forest fires occurred throughout the 12 Northeastern States, possibly setting an all-time record. For example, more than 4,800 fires occurred in Massachusetts during the month of April. The need for improving the effectiveness of prevention measures is evident.

Disaster struck New Jersey on the weekend of April 20-21. Several large fires resulted in the death of 7 persons and burned over nearly 200,000 acres of forest land, destroying many homes in the process. Other states also experienced large fires, and a

Measured moisture content of surface litter in a New Jersey oak stand compares favorably during the cured herbaceous stage with fine fuel moisture readings taken from table 1 of the Preliminary National Fire Danger Rating System.



number of homes were burned on that weekend. A review of the weather records indicated that April 20 was probably the most severe day for fire in the past 50 years in New Jersey. The difficulties experienced in controlling these fires point up the need for improvements in suppression equipment and techniques.

A paper dealing with the spring fire season in the Northeast, with particular emphasis on New Jersey, was presented to the Forest Fire Division at the national meeting of the Society of American Foresters in Boston in October and will appear in the Proceedings.

FOREST RECREATION

PROBLEM SELECTION

AN INTENSIVE analysis of research problems in forest recreation in the Northeast has been under way ever since the project was established in 1959 at Warren, Pa. During the past year a formal problem selection was prepared, drawing together and outlining six problems for recreation research in the Northeast—an intermetropolitan region where more than one-fourth of the Nation's people live on about one-sixteenth of the Nation's land. The six problems are as follows:

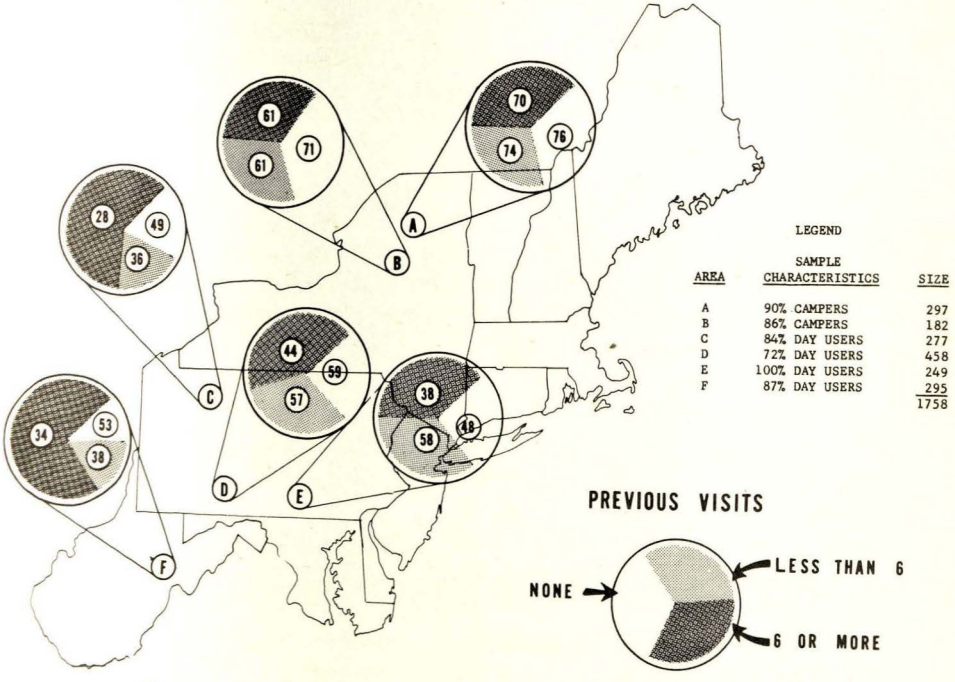
1. **The natural landscape.** What methods of managing the forest landscape will provide for the greatest welfare and satisfaction to the visitor seeking recreation in the forest, for the best allocation of the recreation resource, and for the greatest protection of the forest at least cost?
2. **The developed resources.** What type, amount, distribution, and combination of structures will best provide the people with forest recreation in a safe, healthful environment and at a reasonable cost?
3. **Estimating present use and demand.** How may reliable estimates be made of the present volume, type, and distribution of use and demand by people for the various resources, facilities, and activities in the forest?
4. **Predicting future recreation demand.** What social and economic forces in metropolitan centers influence recreation in the surrounding regions, and to what extent in the future will these forces exert pressure upon the forest recreation resources?
5. **Financial aspects.** What are the costs and returns of the various types and sizes of forest recreation installations in relation to their organization, management practices, location, and other factors affecting financial efficiency?
6. **Evaluation of social and economic benefits of the use of forest resources for recreation.** How may recreation values be determined and compared with other multiple uses of forest land, or with other single competing uses for forest land?

From this list, three problems have been selected for high-priority research during the next few years by the Warren project: *the natural landscape, the developed resource,* and *estimating present use and demand.*

VISITOR CHARACTERISTICS

In last year's annual report, we described results of a study of attitudes and preferences of people on the Allegheny and Monongahela National Forests. This year, results include a later extension of the same questionnaire study to four state parks in New York and Pennsylvania.

Although these later results tend to substantiate earlier results —especially in showing differences in people's attitudes and preferences—the results also show that recreationists appear to be somewhat different from the population at large. For example, the 1960 census indicated that about 30 percent of the adult labor force had incomes in excess of $6,000, but a sample of 1,700 recreationists in the Northeast revealed that on all areas



The percentage of recreationists earning more than $6,000 annually, by classes of previous visits at six recreation areas in the Northeast.

sampled the proportion of recreationists in the $6,000 or above bracket exceeded the National figure. The range was from a low of 37 percent at a recreation area in West Virginia to a high of 74 percent at a campground in New York.

Inter-area differences in recreationist attitudes or preferences are not readily explained, although they probably are related to the fact that people exercise a variable degree of selectivity in their choice of recreation areas. And until this selectivity or "self-stratification" is better understood, it will not be possible to obtain representative samples (on a regional basis) of recreationists by any on-site methodology that concentrates on large, accessible recreation areas.

An illustration of a selective mechanism among recreationists is found in the comparison of visitors who have previously been on an area to those who have not. If recreationists select their recreation areas partly on the basis of association with people of equal or similar status, then the subsamples of first visitors can be expected to differ significantly from that of repeat visitors; these differences are further stratified by income classes. First-time visitors seem to have a higher income grouping at all areas. Also, visitors at day-use areas showed greater variability in incomes among the three visitor classes than did visitors at campsites. Further analyses indicate a persistent high level of enjoyment among repeat visitors, especially among campers.

PHOTO-CHOICE SURVEY

What kind of outdoor recreation facilities do people prefer? And are they willing to pay for their preferences? Today's recreation planners and administrators want to know the answers to these questions so they can provide maximum service and enjoyment for the recreationist.

During a 2-week period in mid-July 1962, a photo-choice personal interview survey was conducted on four state parks in northeastern Pennsylvania: Hickory Run, Promised Land, Ricketts Glen, and Tobyhanna. Park users, including both day-use visitors and campers, were asked to examine black and white photographs of different kinds of swimming beaches, picnic areas, fireplaces, sanitation facilities, campsite spacings, and camping facilities, and to designate their preferences after considering the cost per day they would have to pay to use each facility. Cost figures represented a realistic use fee for the construction, maintenance, and expansion or replacement of individual facilities.

Survey results indicated the following preference patterns of outdoor recreationists. A beach should have about 50 percent of its area covered with shade trees. A small proportion of recreationists wanted to swim in a natural stream. Overstory canopy in picnic areas should be diversified: a low-canopy of softwoods (40 percent), an open area with scattered trees (40 percent), and a high canopy of hardwoods (20 percent). More than 85 percent of the respondents wanted flush-toilet facilities. Large stone fireplaces and small metal fireplaces each accounted for approximately 40 percent of the choices. Other recreationists had portable stoves or grills and did not require any fireplace facilities.

Campers preferred tenting or trailer sites rather than cabins by almost 2 to 1, whereas non-campers preferred cabins by almost

The abundance of low-growing plants as affected by camping in the Buckaloons Recreation Area. The trend line of percent loss in low plant cover over number of camper-days is based on vegetation measurements taken on 52 sample plots in May and September 1963.

The Buckaloons Recreation Area on the Allegheny National Forest in Pennsylvania provides two campsite units along the Allegheny River. At left is the site of the new Forest Recreation and Wildlife Laboratory, now under construction.

3 to 1. Adirondack shelters were preferred by 10 percent of the campers. About two-thirds of the campers were satisfied if they could camp 50 to 100 feet from other campers; another third wanted to camp 250 to 400 feet apart; and a very small proportion of campers favored campsites 10 to 15 feet apart. Most respondents expressed a willingness to pay an appropriate use fee for the recreation facilities they chose.

RECREATION IMPACT

One season of recreational use resulted in an average loss of 39 percent of the ground cover vegetation in a previously unused campground of the Buckaloons Recreation Area on the Allegheny National Forest. Campsites receiving light use, or about 150 man-days, averaged a 15-percent loss in vegetative cover, while sites receiving twice this use-intensity averaged a 65 percent loss in ground cover.

Thus, as expected, there was a very strong relationship between the intensity of campsite use and the loss of low-growing herbaceous cover. However, on the basis of 1 year's results, there seems to be a good indication of variability in the tolerance of ground cover types. Species such as sheep sorrel, cinquefoil, and mosses appear to be able to withstand light to moderate camper use. Wild strawberry, violets, goldenrods, and associated species, were found to be intolerant of anything more than light use. The most resistant species were mixed grasses and weeds, with Canada bluegrass predominating.

THE BUCKALOONS RECREATION AREA

An experimental recreation area, the Buckaloons, was constructed in 1962-63 on a portion of the Irvine Demonstration Forest Area of the Allegheny National Forest in Pennsylvania. A 15-unit camping area with a 4-unit flush toilet was set up along the bank of the Allegheny River. Back from the river in the big loop area is a 40-unit campground with a 7-unit flush toilet. Water for both of these areas is provided at five well-spaced stone fountains.

A mile-long interpretive trail follows the river, turns up along the smaller tributary Brokenstraw and Irvine streams, then swings around back to the river near the bridge. Access to the river is provided at two places. At one end of the area there is a boat-launching ramp, served by a small road loop. At the other end steps give easy access to the river's edge.

The Buckaloons Recreation Area is operated by the Allegheny National Forest with special provision for recreation research. Several studies are under way on the area, and more will be started in the future on various types of facilities and equipment. In other studies on the area we will investigate the attitudes and preferences of campers, picnickers, and users of interpretive facilities.

WILDLIFE HABITAT

THE program for wildlife habitat research at Warren was analyzed during the past year, and a problem selection was made, formalizing the work of the project. The five major research problems defined—(1) techniques and methods of habitat management; (2) wildlife-timber relations; (3) special practices for habitat improvement; (4) ecology, physiology, and nutritional value of wildlife plants; and (5) wildlife valuation—will be studied. The forest game species involved are deer, ruffed grouse, turkey, snowshoe hare, rabbit, gray squirrel, and black bear.

However, because of the magnitude of the problem presented by each game species, and the small staff (one man) for the research project, attention will be focused only on deer and ruffed grouse during the next 5 years. These species were chosen because of their importance as game species, their wide distribution in the Northeast, and the apparent close relationship between the management of their habitat and the management of forest land for timber production. Current habitat studies are concerned entirely with these two species.

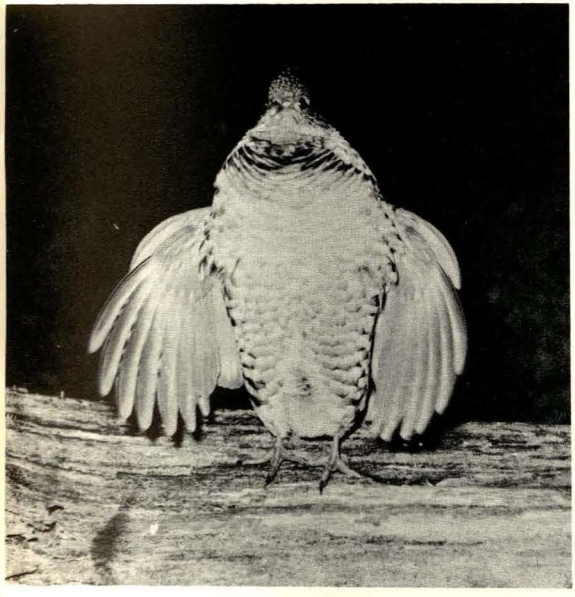
GAME RANGE

The recent cooperative agreement with the Fish and Wildlife Service, which resulted in the assignment of Ward M. Sharp to Warren, will permit an expansion of the scope of some research by joint study of both game species and habitat.

Another result of this agreement is the introduction of the game-range concept in the management of habitat. It visualizes the game range as the smallest unit of area that will satisfy the year-around needs of a local population of any game species and is therefore the logical unit for management. Under proper management, the game-range produces a shootable surplus of the game species. Its size is determined by the distribution of essential habitat components. For ruffed grouse, this is probably 200 to 500 acres—or about the size of management compartments on eastern National Forests. The game-range concept will be tested in our grouse research to find methods that will yield a better balance among game species and a greater diversity in hunting.

HEMLOCK FOR GROUSE COVER

One of our cooperative studies with the Fish and Wildlife Service is concerned with methods of re-establishing hemlock cover for ruffed grouse in selected areas. Although hemlock is unequaled in value as cover, its effective distribution has declined in much of its commercial range in the Northeast. The common occurrence in northeastern forests of large permanent openings, understocked, orchard-type hardwood stands, and extensive areas of hardwood poletimber stands — all devoid of patches of coniferous cover and low in grouse production—suggests that such areas may be improved for grouse by the selective addition of hemlock cover.



A male ruffed grouse drums from a log at dawn. Drumming sites like this one are one of the essentials in habitat for grouse during the spring mating season.

As a first step in exploring this possibility, 3-year-old hemlock seedlings 4 to 8 inches high were planted in openings of high weeds and grasses, in orchard-type hardwood stands providing partial shade, and in dense, heavily shaded poletimber stands. After one growing season the growth of seedlings was best in the orchard stands and poorest in the open areas. Within the orchard type, the best growth was in seedlings planted on north-facing slopes. The survival of the seedlings was also highest on

north slopes in the orchard stands, although the survival of seedlings under all conditions was considered satisfactory.

The protection provided by partial shade on north-facing slopes appears at this point to be best for the establishment of hemlock cover. As is so often the case with forest habitat research, results are eagerly awaited for use in habitat management. In this instance, a planting program for hemlock on the Allegheny National Forest in 1964 will utilize these early results in the selection of planting sites.

CUTTING FOR BROWSE AND TIMBER

The most important current practice in the production of woody deer browse in the Northeast is harvest cutting under even-aged management in which patches or blocks of timber are clear-cut. However, even with the increasing trend toward even-aged management in northeastern forests, harvest cutting probably will not obtain the distribution of browse required for good deer management. So habitat research has been directed toward the possible use by adaptation or modification of other timber-management practices for the dual purpose of producing both browse and timber.

One promising practice, reported on last year, is thinning young hardwood stands. This practice is being studied under a cooperative agreement between the Pennsylvania Game Commission and the Station. In the study, five levels of thinning to residual basal areas of 60, 45, 30, 15, and 0 square feet per acre were employed in northern hardwood poletimber stands. Although the results of this study are not conclusive at the end of 2 years, the results plus good judgment—tempered by knowledge of other factors in the study — do permit us to make some preliminary decisions as to the best level of cutting.

These preliminary results are now in use as general guidelines in thinning similar stands on State Game Lands in Pennsylvania, where the previous practice was to clear-cut or bulldoze all but the good mast-producing trees. Also, as a direct result of this study the Allegheny National Forest is felling all trees except the crop trees—rather than girdling only the competing stems, which is the common practice in noncommercial thinnings—in 10-acre blocks spaced 1/4 mile apart in pole-size hardwoods. After 1 year there is a striking increase in browse production on these treated areas, although the basal area of crop trees has been held to 80 square feet per acre.

WATERSHED MANAGEMENT

OUR watershed researchers had a year that was reasonably productive — even when viewed through the somewhat curious notion that substantial progress on long-term projects can be reported on an annual basis. As an innovation, this year we will try to identify research results with researchers, supplying for our readers at the end of this report proper identification for our cast of characters, both Station personnel and cooperators.

REGIONAL STUDY

Our continuing desire to relate watershed research results to our region's varieties of climate and physiography has led us to a regional study of streamflow. Specifically, we attempted to determine if major physiographic regions in the Northeast have characteristic streamflow regimens. We were also curious to find out how the amounts and distributions of streamflow from our small forested experimental watersheds compare with the streamflow of much larger watersheds in their locality. For data we selected, from U. S. Geological Water-Supply Papers, 17-year records of streamflow (1940-57) for 137 watersheds with areas of 100 square miles or less. These watersheds were scattered across 10 states from Maine to Maryland.

Prof. William Sopper of The Pennsylvania State University joined Howard Lull of our staff in this study and also provided the computing facilities necessary for boiling down almost a million numbers into meaningful figures on runoff, storm flows, and flow durations. For all watersheds the average annual water yield turned out to be 22 inches; annual values ranged from 19 to 24 inches. By seasons, the water yield was distributed as follows:

	Inches
Spring (March, April, May)	10
Summer (June, July, August)	3
Fall (September, October, November)	3
Winter (December, January, February	6

Summer and fall values ranged around 2 to 4 inches for the seven regions considered (Northern New England Upland, Southern New England Upland, New England Seaboard, Glaci-

ated Plateau, Ridge and Valley Area, Northern Piedmont, and Coastal Plain), and winter from 4 to 7 inches. Spring runoff was most variable, ranging from 13 inches in northern New England to 6 inches in the Coastal Plain of New Jersey, which illustrates the influence of the greater snow accumulations in the north.

As had been hypothesized, there was a significant difference (1-percent level) in annual and seasonal runoff between regions; but there was also a significant difference within regions—which dashed our hopes of extending our research results to physiographic regions of relatively uniform runoff. Further underscoring this variation was the fact that, even within a 30-mile radius, clusters of 11 to 18 watersheds had significant differences. We have not given up. As a next step, we are assembling climatic and topographic data for each watershed for continuing analyses to derive methods for predicting watershed streamflow.

More rewarding was a comparison of runoff from our small experimental watersheds with that from the much larger areas comprising this study. Take one example, a comparison of runoff of our 29-acre Hubbard Brook watershed No. 1 in 1959-62 with the runoff in 1940-57 of 18 watersheds in northern New England that averaged 45,632 acres in area:

		Runoff by seasons			
	Annual runoff (inches)	*Spring (%)*	*Summer (%)*	*Fall (%)*	*Winter (%)*
Northern New England	23.40	55	12	14	19
Hubbard Brook	25.74	61	4	17	18

The evident agreement suggests that our small experimental watersheds may possibly serve as models for the much larger ones, and that the apparent gulf between small to large watersheds, for application of results in this region, may not be so great as had been thought. The agreement probably stems from the fact that our experimental watersheds have perennial flow and about the same climate as the much larger ones.

NEW YORK STATE'S WATERSHEDS

Forest watershed management needs in New York State were the subject of another cooperative endeavour—this one by Professor Donald Satterlund (Syracuse) and Arthur Eschner. According to their report, this generally-acknowledged well-watered and well-forested state has real water problems that stem from

major shifts in land use in the last three decades, and from a water supply that, though seemingly generous, is often inadequate during summer months when demands are greatest.

The potential of forest lands for ameliorating flood waters, particularly in the Allegheny Plateau, is not known, and we suspect it is not fully exerted. And in New York we have the situation, common through much of the Northeast, of great metropolitan areas not only depending on unmanaged forest watersheds to furnish ever-increasing supplies of water, but doing so without a solid foundation of knowledge. In forest watershed research, nowhere is so little done for so many.

SNOW STUDIES

Publication of the results of snow studies in central New York by Eschner and Satterlund, and in southern New Hampshire by George Hart, together with our 1959-60 studies in the Adirondacks, helped to fill out our regional picture of forest snow accumulation and melt.

In these areas snow usually begins to accumulate in December and builds up to a maximum depth (whose variation can be related to canopy density) about mid-March. At any time during this period, the accumulation beneath the canopy is the residual after subtractions by interception and melt. Just before the maximum accumulation begins to melt, snow density is about 30 percent. Roughly, the accumulation under hardwoods may then be 1½ to 2 times as great as under conifers; snow under the hardwoods will melt about twice as fast as that under the conifers.

Continued analysis by Eschner and Satterlund of these and other data is pointing up the fact that, in regard to flood flows, the retention of snow by the forest may not always be desirable. The longer the snowpack persists in the spring, the greater the likelihood of rapid melt by warm spells. The timing of this warmth may change the forest influences on snow accumulation and melt from favorable to unfavorable, so that calling the forest the guardian of the watershed may be a misnomer—at least in certain locations.

SILVICIDES ON MUNICIPAL WATERSHEDS

A question that has concerned municipal watershed managers is the possibility of using 2,4,5-T silvicides to control woody

Applying silvicide on a Fernow Experiment Forest "benchmark" watershed, in a study to determine how manipulation of vegetation affects streamflow.

vegetation along streambanks and reservoir shorelines. Custom and opinion had limited their use from fear their phenol constituents would impart noticeable taste and odor to the water.

To test this, Irvin Reigner, with cooperators William Sopper and Roy Johnson (Amchem, Inc.), sprayed the banks of two small streams near Newark, N. J., and State College, Pa. Water samples, taken periodically thereafter, were tested by a taste and odor panel. Odors were detected in the samples taken immediately below the treated stretch immediately after spraying. About a mile downstream, no odors were detected.

From the results of this study and a number of other considerations, the researchers concluded that the 2,4,5-T silvicides, properly applied, can be used on municipal watersheds without contaminating the water. An interesting sidelight of this test was that the people on the testing panel could consistently detect quantities of the silvicides as small as 20 parts per billion in water.

MINIMUM STREAM-GAGING

Another question studied this past year pertained to the frequency of streamflow measurements required to determine how forest cutting affects water yield. Watershed managers on national forests, for instance, are interested in determining the

effect of their management practices on water yield. But what streamflow measurements are required? Is it necessary to take continuous records?

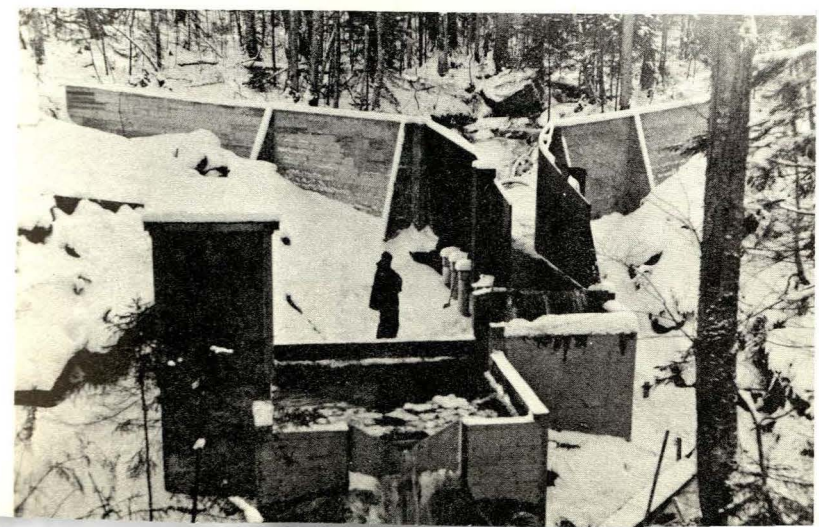
To get some ideas about this, Kenneth Reinhart analyzed the streamflow records of the control and clearcut watersheds at the Fernow Experimental Forest to find out whether or not the effects of clearcutting on water yield would be evident if measurements had been taken daily, twice a week, weekly, twice a month, or monthly. Somewhat to our surprise, he found that the occurrence of annual, growing season, dormant season, and monthly changes could be detected with once-a-week measurements as well as with continuous measurements, and almost as well with once-a-month measurements.

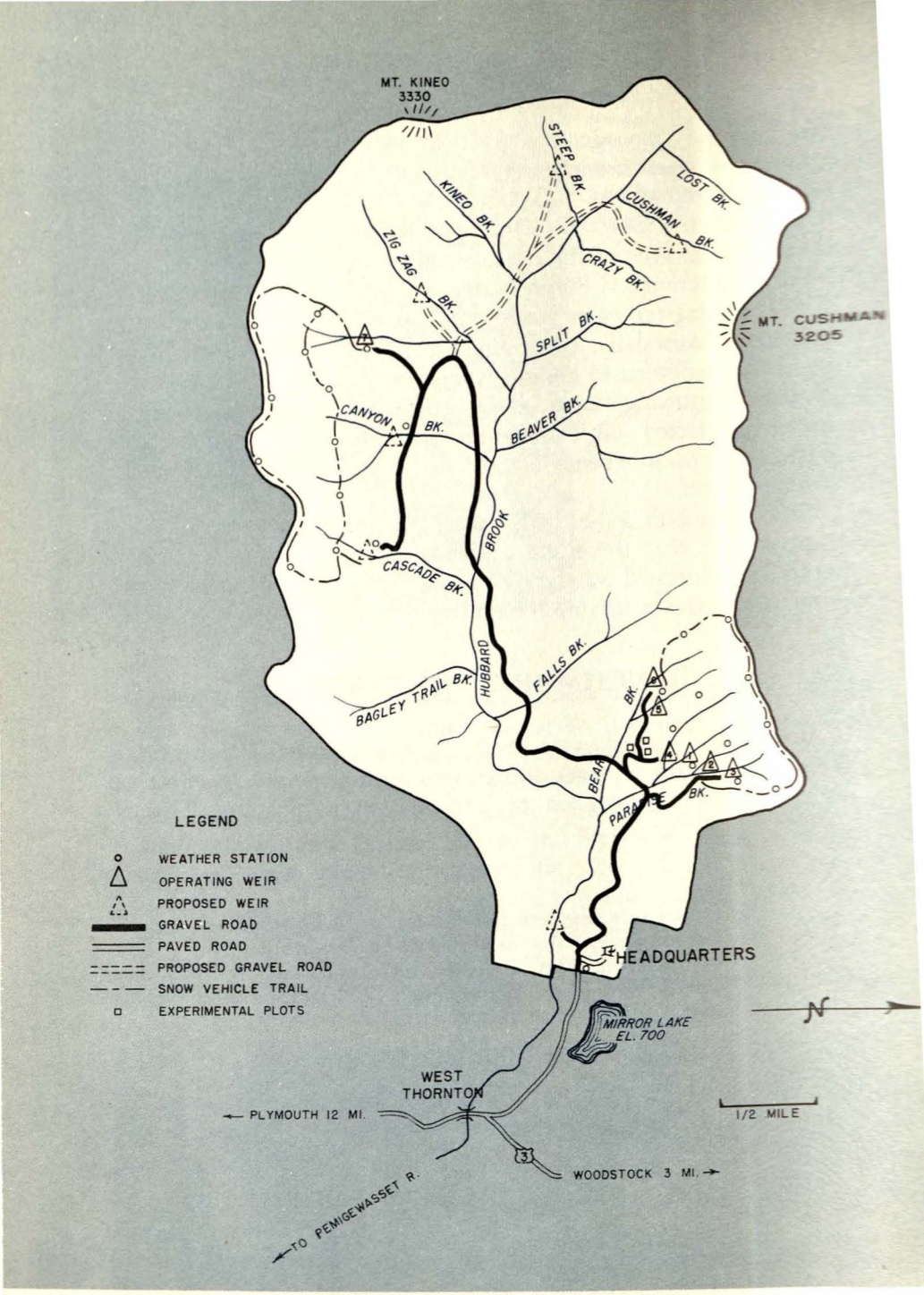
Still subject to some qualification, these results seem to offer a possibility that the effect of management practices on water yield from forested watersheds can be measured without recourse to a continuous water-level recorder.

"BENCHMARK" WATERSHEDS

Two small gaged watersheds on the Fernow Experimental Forest are being cut over and treated with silvicides to effect as near complete elimination of transpiration as possible. This is

Progress in research installations at Hubbard Brook Experimental Forest: the new stream-gaging station No. 7, just before completion. It consists of a combination 4-foot San Dimas flume and a 1¼-foot-high 120° sharp-crested V-notch weir.





The watershed research installations at Hubbard Brook Experimental Forest, West Thornton, New Hampshire.

a more complete treatment than the recent commercial clearcutting. The objective is to determine the maximum change in streamflow that can be accomplished by manipulation of vegetation.

The watersheds will be cut in two stages, upper and lower halves, to find out whether the location of cutting has any appreciable effect. After cutting and silvicide treatment, one watershed will be planted to conifers and the other will be allowed to revegetate naturally.

PROGRESS AT HUBBARD BROOK

Since May 17, 1955, when the Hubbard Brook Experimental Forest was set aside for watershed research, there has been almost a continual round of road-building (there was no road into this 7,500-acre watershed), weir building, climatic measurements, plot studies, and office and shop construction. This past year weir No. 7 was completed, and sites were prepared and materials assembled for weirs No. 8 and No. 9. An access road was also completed to a stream-gaging site on the main Brook.

RESEARCH IN SUBURBIA

What happens to the infiltration capacity of forest and farm land when the bulldozers move in and a suburban housing development springs up? This question was dealt with in one of our smallest yet most provocative studies completed this past year.

A Philadelphia suburb was studied by Howard Lull, in cooperation with Paul Felton, then executive director of the Wissa-

Research invades the backyards and front lawns of suburbia — and draws the curious youngsters! — in a small study to determine what happens to the water-absorbing capacity of the soil when land use is changed from forest to residential area. The object the youngsters are inspecting is an infiltrometer.

hickon Valley Watershed Association, Fort Washington, Pa. Infiltration runs were made in woods and open fields, and on suburban lawns. Related to proportionate land use in the Wissahickon Valley, the results showed that, as the area changed from forest and field to suburban lawns, streets, and driveways, there was a reduction in relative infiltration of about one-half.

INSTRUMENTATION

As in the past, some time was spent on instrumentation. Irvin Reigner compared rainfall catch in conventional standard cans and in rain-trough gages that have been used in the past to measure rainfall under vegetation. Appropriate adjustments were calculated to account for rain-splash from the troughs.

James Hornbeck at the Fernow Experimental Forest set up instrumentation to collect micro-climatic data on a watershed before it is cut, and will continue measurements after cutting to determine the effect of cutting on air and soil temperatures and on evaporation. And Robert Pierce, at Hubbard Brook, tried a number of ways of introducing neutron-probe access tubes into the glaciated stony soil to measure soil moisture, but finally ended up using a combination of a hand auger and power-driven auger.

Water-level recorders traced off another year's record on the 28 watersheds operated by our cooperators throughout the region: John Heilman (Newark), Lou Ningard (Baltimore), Bill Sopper (Penn State) and by our own people: Burley Fridley, Irv Reigner, Karl Nicholas, and Ray Lavigne.

PERSONNEL

George Hart returned to Hubbard Brook after 2 years' study at the University of Michigan in hydrology; Ray Leonard left for Yale University for 1 year's study in forest meteorology.

The cooperators in our watershed management research, previously mentioned in this report, are:

John Heilman, forester, Pequannock Watershed, Newark, N. J.

Louis Ningard, watershed manager, Bureau of Water Supply, Baltimore, Md.

Donald A. Satterlund, professor of watershed management, New York State College of Forestry, Syracuse, N. Y.

William E. Sopper, professor of watershed management, School of Forestry, The Pennsylvania State University, College Park, Pa.

Paul Felton, technical director, Water Resources Association of the Delaware River Basin, Philadelphia, Pa.

Roy R. Johnson, forester, Amchem Products, Inc., Minneapolis, Minn.

Station personnel engaged in our watershed research are:

At Laconia, N. H. (Hubbard Brook Experimental Forest): Robert S. Pierce, George E. Hart, Ray Leonard (now on educational leave), and Ray Lavigne.

At Syracuse, N. Y.: Arthur Eschner.

At New Lisbon, N. J.: Irvin C. Reigner and Karl Nicholas.

At Parsons, West Virginia (Fernow Experimental Forest): Kenneth G. Reinhart, James W. Hornbeck, and Burley D. Fridley.

At Upper Darby, Pa.: Howard W. Lull.

FOREST INSECTS

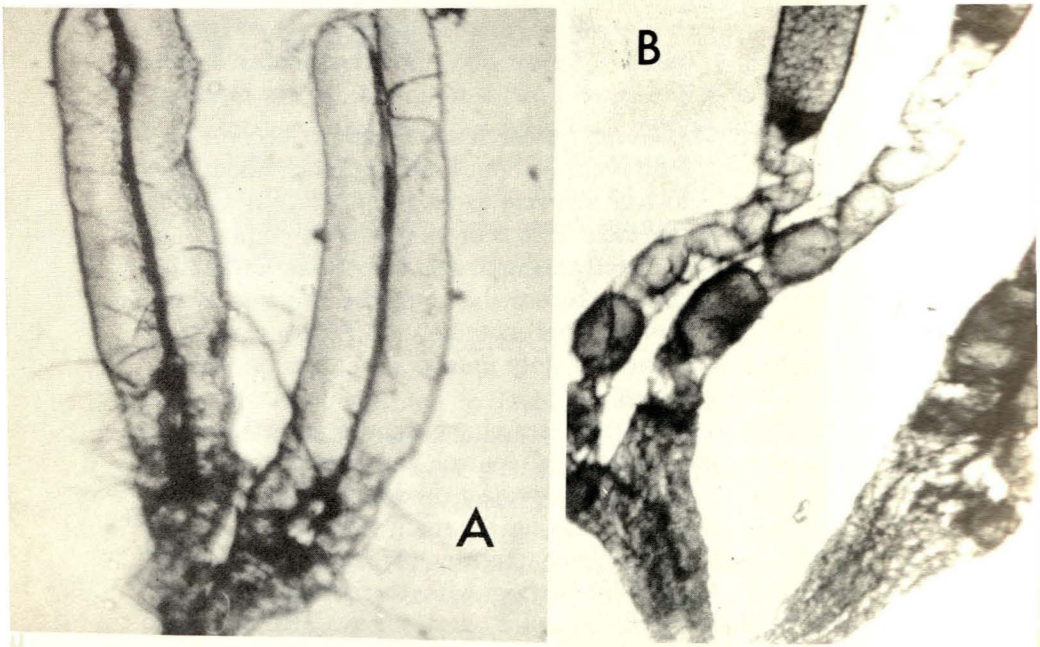
IN ANY aspect of forestry research it is easy to become involved in solving a problem without knowing much about the system in question — to seek answers to *why* something is as it is before finding out really *what* it is. For example, in combatting destructive insects in the forest, research zeal sometimes has led to experiments with insecticides before the complete life history of the target insect was known. And most control experiments still are truncated to the extent that only immediate effects on the insect population are measured.

Our program in forest-insect research embraces four major lines of inquiry: biotic control, chemical control, insect impact, and insect biology. The last is the core project, in which we attempt to provide the essential information on the main actor — the insect. Studies are made of the intrinsic qualities of primary pests, and the environmental factors interacting with them that determine reproduction, development, behavior, and survival. In all four projects, however, the work is conceived and planned insofar as possible to provide sufficient basic information on the biological materials, processes, and systems concerned so that our research can proceed efficiently and soundly. Following are some highlights of our insect research program in 1963.

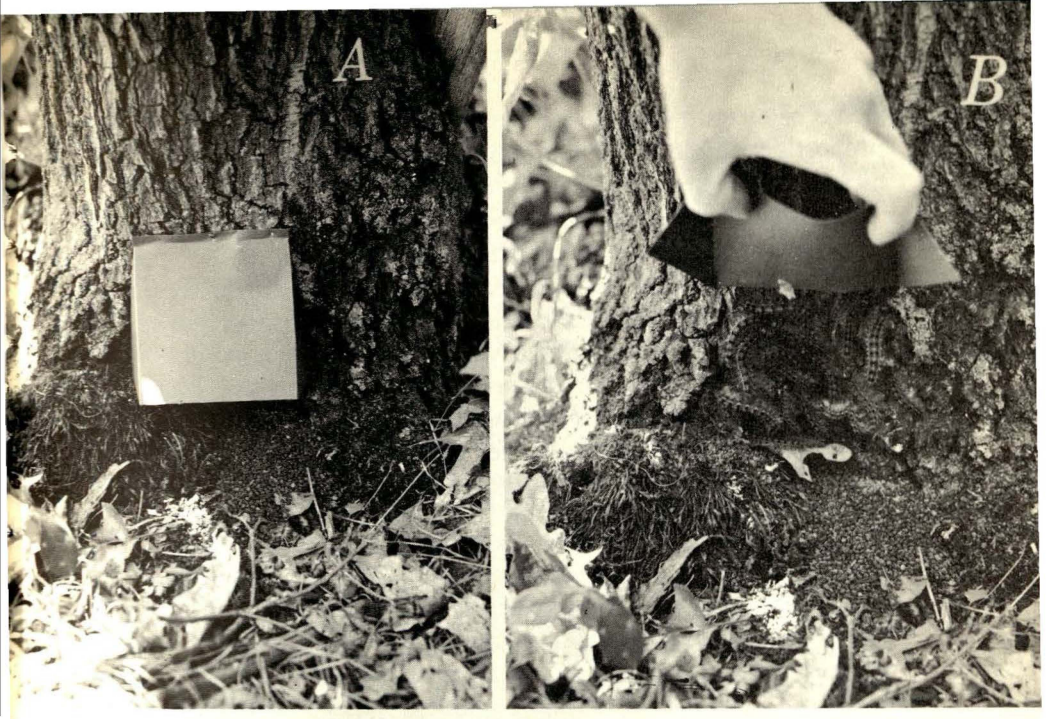
INSECT BIOLOGY

Insect development is regulated largely by the neurosecretory system. Adaptive dormant periods (diapause), mediated by environmental factors such as photoperiod and temperature, are triggered by secretions from the insect brain. And development of the reproductive organs similarly is controlled by neurosecretions. Study of the neurosecretory system of the white-pine weevil and related species of *Pissodes* has been initiated to find out how the weevil's particular rhythm of development and activity is controlled and how the regulatory apparatus differs among the *Pissodes* common to this region.

Thus far we know that diapause of the white-pine weevil is obligatory. But it can be shortened markedly in the laboratory by the manipulation of temperatures. Also, egg development in the adult female proceeds slowly. The ovaries are well developed by the time the young female emerges from the leader of a host tree,



Ovary and egg development in the white-pine weevil. A, magnified whole-mount of living ovary removed from an adult female in August—no eggs formed as yet. B, similar view of ovary taken from female in January—eggs present in successive stages of development.



A rendezvous for gypsy moth larvae. A, an artificial niche in place. B, togetherness: the niche cover raised to show larval aggregation. (Photos courtesy of N. Y. State Museum and Science Service.)

but no eggs are formed. The eggs are discerned in dissected individuals later in the fall, but they are not fully developed until mid to late winter. Since insemination by vigorous males often takes place in the fall, some protective mechanism such as the delayed egg formation noted is needed to prevent reproductive wastage.

Analyses are being made of the neurosecretory activity in adult weevils through differential staining of sectioned brain tissues, but the correlation with diapause and development of the reproductive organs and other functional parts has not been worked out yet.

New field sampling and analytical techniques have been utilized in studying the dynamics of gypsy moth populations. This insect is highly mobile in the larval stages, so it is difficult to sample efficiently. This is particularly so when a population is sparse. However, the large larvae have a strong tendency for togetherness, and the aggregative patterns formed are maintained to the adult stage. This habit has been exploited by using artificial

niches of opaque vinyl plastic or burlap on host trees. A very high proportion of the gypsy moth larvae in a site find and use these niches each day.

Detailed observations and regular counts of the gypsy moth in successive stages have been made in the artificial niches at special study sites in eastern New York for 2 years. The data obtained show clearly when the larvae begin to aggregate on the tree stems (in late instar III) and how they aggregate according to the kind and position of niche on the tree. Using the negative binomial parameter k as the measure of aggregation, we found a consistent difference in the calculated values for type and position of niche, site, host tree species, and stage of development. The k values were obtained by the maximum likelihood solution, programmed for the IBM 709.

Since the manner and degree of aggregation, or spatial distribution, of an insect (or any living creature, including man) may affect its chances for survival, further analysis was made to determine if this was a significant factor in the population dynamics of the gypsy moth. Using a simple index of vertical distribution, the average percent of egg masses within 1 foot of the ground in each site (for which data were available for a 6-year period), it was found that there was a consistent relationship with population trend. The most meaningful expression of the relation involved the index of vertical distribution combined with two other variables — population density and the proportion of females among adults — in the form of a multiple interaction:

$$I = P \cdot D \cdot v$$

where I = index of population trend,

$$= \frac{\text{Eggs per acre in generation N + 1}}{\text{Eggs per acre in generation N}}$$

P = proportion of females among adults in generation N.

D = number of newly hatched larvae per unit area at beginning of generation N.

v = average percent of egg masses within 1 foot of the ground.

These three "independent" variables accounted for most (over 90 percent) of the variation in index of population trend. It was shown that population trend will increase as the proportion of females increases. And, holding the latter variable constant, population trend decreases as density increases; and at any given density, population trend will be greater as a smaller percentage of the egg masses occur below the 1-foot level. This is so because the egg masses near the ground are most subject to predation by small mammals, ground beetles, and other terrestrial foragers.

The basic model used in the analysis, $I = P \cdot D \cdot v$, is unrealistic in at least one way. It forces the association between I and v to be proportionately the same at all population densities. It is not likely that any true index of spatial distribution and population trend will have the same relationship at all densities. Thus, further analyses are in progress to define this relation more exactly and to provide more insight into the processes involved. This analytic approach will be applicable to studies of other insect populations, also.

Under terms of a cooperative aid project with the University of Massachusetts, intensive study is being made of an insect predator of the red-pine scale, *Matsucoccus resinosae,* that has been found abundant in certain areas presently infested by the scale. The predator, *Elatophilus* (*Xenotracheliella*) probably *inimica,* is one of a family of insects that commonly feed on soft scales and aphids. This species apparently feeds only on the red-pine scale. Pine bark aphids and many other similar forms often associated with the red-pine scale have been offered to *Elatophilus* in the laboratory with negative results.

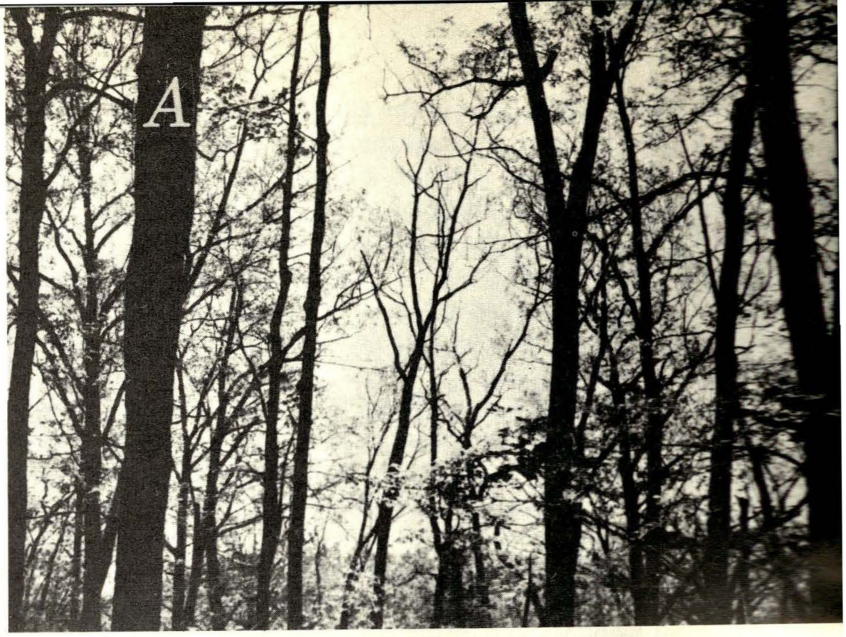
In the field the predator has been found only on red pines infested with the scale. It has two generations a year, closely synchronized with those of its prey. There are five nymphal stages. The larger nymphs and adults search effectively and feed voraciously when caged with different stages of the scale.

BIOTIC CONTROL

Much time and effort this year were given to research on the microbial insecticide, *Bacillus thuringiensis.* Real progress was made, yet technical problems remain in developing a biologically efficient preparation that can be dispersed effectively for practical control.

Field tests of a commercially produced liquid formulation of *Bt* were conducted against the gypsy moth in eastern New York and the spruce budworm in northern Maine. Both experiments were carried out in cooperation with state and other federal agencies. Spraying against the gypsy moth was done by airplane; a helicopter was used for the budworm treatments.

For the gypsy moth, a dosage of ½ gallon of the liquid *Bt* concentrate in 2 gallons of water per acre effected over 95 percent reduction in the population, as measured by the difference in number of egg masses at the beginning of the generation and the number laid by surviving females after treatment. A higher dos-

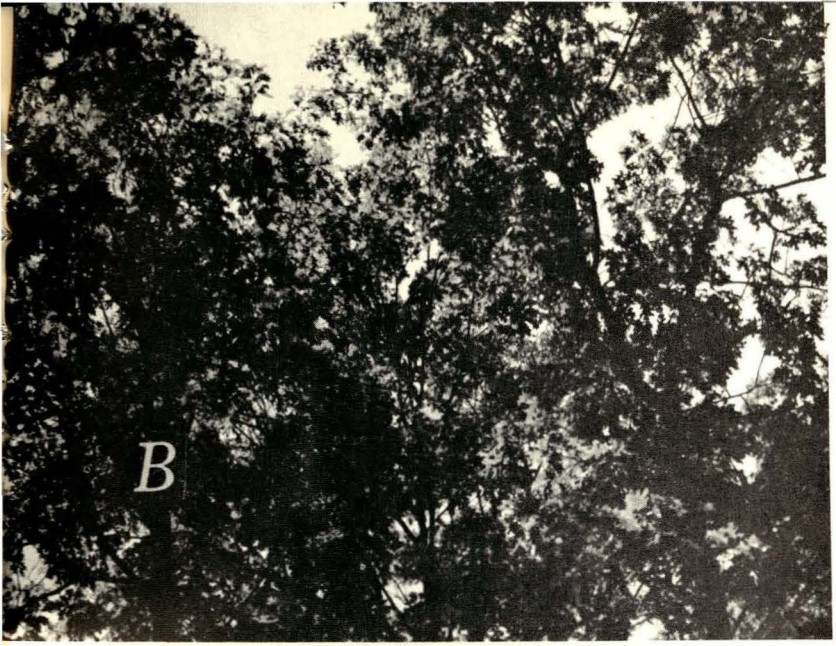


Protective effect of gypsy moth virus spray. A, view of forest canopy in untreated check plot. B, comparable view of canopy in the treated plot.

age (1 gallon of *Bt* concentrate in 2 gallons of water per acre) gave consistently poorer results, producing less than 60 percent reduction in egg masses. However, the actual number of egg masses remaining in the plots after even the best treatment was approximately 100 per acre; and this is not considered satisfactory.

With the budworm, a water spray gave significantly better results than a mixture of the *Bt* in oil. Here too, though, the overall control effected was not satisfactory.

The liquid formulation proved easy to handle in the field, and it was biologically stable after mixing with the diluents. This represented a real improvement over the previously tested wettable powder formulations, which tended to clog spraying apparatus and could not be diluted with water more than 1 day before use. However, certain components of the liquid concentrate had a repellent effect on the insect and may have reduced the killing action of the *Bt* organism itself. Preliminary tests of the material fractionated in a gross way indicated what were the adverse components, and more detailed tests are in progress to delineate them completely. We are confident that truly effective preparations of *Bt* can be developed, each with a high degree of selectivity for a given pest and nontoxic to other forms of life.



Some rather unusual micro-organisms have been isolated from various forest insects by researchers at the New Haven Laboratory and the University of Connecticut. A cooperative aid project in insect pathology with the Bacteriology Department of the University has facilitated this work tremendously. Examples of the results thus far are the isolation of 23 strains of motile, yellow-pigmented streptococci and a *Proteus*-like organism from field-collected gypsy moth larvae. These organisms appear to be pathogenic to the insect. They are the first known records of such microbes from insects.

More detailed laboratory tests and a small-scale field test were conducted with the gypsy moth polyhedral virus. Replicated feeding tests with graded dosages of the virus in the laboratory provided a basis for estimating an LD 50 for instar II larvae — this approximated 23.2×10^6 polyhedra per milliliter, or a field equivalent of about 100 billion polyhedra per gallon.

On this basis, application of the virus was made by a truck-mounted mistblower in a moderate to heavy infestation in the White Memorial Forest, Litchfield, Conn. The spray mixture contained 1 trillion polyhedra per gallon — 500 times the dosage previously tested in the field — and 4 gallons were applied to a measured 1-acre plot. The first wilted caterpillars were found in the spray plot 15 days after treatment, and mortality continued up to 35 days (or until pupation occurred). No virus-killed larvae were found in two adjacent check plots. Egg mass counts in the

Placing gamma-irradiated gypsy moth male pupae in experimental area. The container already fastened to tree contains a known number of normal males; normal, expectant females are nearby.

treated plot indicated a residual of 45 egg masses per acre, while the check plots averaged 250 per acre. The direct control effect of the virus spray was further shown by a marked difference in the degree of defoliation in the treated and check plots.

Examinations will be made in the experimental area in 1964 to determine if the disease intensifies and spreads naturally.

Opportunity was provided this year to apply the sterile-male release technique to the gypsy moth in the field. In cooperation with the Methods Improvement Laboratory on Cape Cod, known numbers of normal females, normal males, and gamma-irradiated males were placed in a "clean" white pine plantation in replicated units. The treated males were irradiated from a Cobalt-60 source at the Brookhaven National Laboratory while pupae; and all releases were made in this stage. The treatment used was 20,000 roentgens, which had been shown by earlier experiments to produce a high degree of sterility with no unwanted adverse effects on the males.

In the experimental area, the emerging males successfully mated with available females and egg masses were laid subsequently. It is expected that the end result will reflect the relative numbers of irradiated and normal males and the effect of competition between them. All egg masses that were laid have been collected and are being held in cold storage for hatching in March. Only then will we know whether this control technique is effective for the gypsy moth. In practice it necessarily would be restricted to sparse populations in isolated and peripheral areas.

CHEMICAL CONTROL

Studies with synthetic chemicals were limited this year. Proper investigation of new insecticidal materials and more efficient methods of application require personnel and equipment not presently available.

Additional field tests were made this year with a repellent-deterrent chemical to inhibit twig feeding of the smaller European elm bark beetle, the primary vector of Dutch elm disease. The material used was ENT 262 (dimethyl phthalate), which had appeared most effective and least injurious to the trees in previous tests. Several concentrations and rates of application were tested on small American elms planted at the Saltonstall Experimental Area, Branford, Conn. Confounding with beetle mortality was minimized by reducing the test period. None of the treatments prevented feeding by the beetle entirely.

Because of the sustained interest in obtaining regeneration of white pine by natural seeding, and the sometimes devastating effect of the while-pine cone beetle on pine seed crops, we are continuing to look for a means of controlling this pest. Its particular life history and mode of attack make it nearly invulnerable to sprays applied externally to trees.

Eighteen systemic materials have been tested for toxicity to the cone beetle at the New Haven Laboratory. Several proved highly toxic and one of these, Bidrin, was introduced into test trees at the Saltonstall Experimental Area and the Massabesic Experimental Forest, Alfred, Maine. The insecticide was translocated to the cones, as evidenced by mortality of beetles therein, and the cones completed development with no apparent injury. Systemic insecticides appear very promising for control of this and similar insects that feed and breed within the tree.

INSECT IMPACT

This area of study is indeed tenuous, complex, and difficult. Here, the interactions of all destructive agents in the forest merge with economics and management. Clarification is needed as to just what constitutes impact by destructive insects, and methods of evaluation must be developed to properly place such considerations within the framework of management decisions. A problem analysis is being made to guide us in a reasonable course of study.

One tangible contribution was made this year — a guideline for evaluating and scheduling white-pine weevil control in the North-

east. Developed in conjunction with our Station Division of Forest Economics Research, this guideline integrates economic and entomological factors with management objectives in a way that the man on the ground can understand and use. It provides a sound basis for selecting white pine stands that will return a profit on the control investment and gives a step-by-step procedure for scheduling control in the selected stands.

The initiation of treatments, and the frequency of treatment thereafter, is geared to the number of trees per acre remaining free of weevil injury and their rate of growth relative to specified numbers of crop trees per acre and merchantable heights. The analysis made and the guideline itself will serve as the prototype for evaluating impact and making control decisions on other destructive pests.

FOREST DISEASES

BECAUSE the relative importance of our major tree diseases is constantly subject to change and our knowledge of certain of them continues to increase, our program of research must necessarily be flexible. Whenever one encourages flexibility in research there is increased need for direction.

During the year the known forest-disease problems in the Northeast have been reviewed by the Station's pathologists. Our deliberations involved: (1) priorities of disease problems and individual studies within disease problem areas; (2) the depth of research needed to solve some of our most pressing problems, and the possible ways of obtaining such depth; and (3) the direction of our research, including needs in manpower and facilities and realignment of projects.

This annual report does not reflect a change in emphasis. We hope that the change will occur through increased perceptiveness in our research and a greater usefulness of our publications.

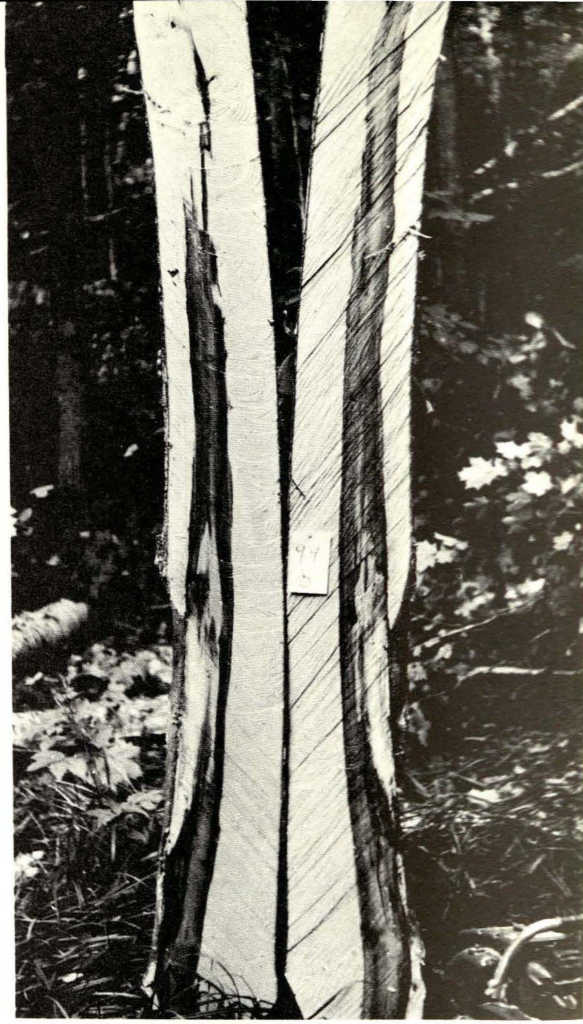
WOUNDS OF NORTHERN HARDWOODS

Trees wounded in past logging operations are being studied to determine the principal organisms that infect wounds and the factors that affect their invasion of the wood in living trees.

This sugar maple, injured at the base, is being felled for dissection and study. The smooth white face on the wound usually indicates very little defect. With a modern chain saw, the pathologist can now rather easily perform tree dissections that would have been extremely difficult a decade ago.

Disks cut through the wound on the sugar maple show the limited defect associated with the wound. After each tree is cut, all external indicators of defect are studied to gain as much information as possible. Internal observations of vigorous trees have also been made.

This sugar maple tree wounded 8 years ago has been dissected lengthwise to expose the decayed and discolored area. The defect is in the most valuable portion of the tree.



Trichocladium canadense and a bacterium growing together in culture. These two organisms are frequently isolated together from discolored wood in all species of northern hardwoods. Bacteria are often closely associated with many other wood-inhabiting fungi. We need to know more about these associations of organisms in living trees.

During the last 4 years 380 trees (sugar maple, red maple, beech, ash, yellow and paper birch) from 6 to 24 inches d.b.h. have been studied on the White Mountain National Forest in New Hampshire. The wounds on these trees occurred from 2 to 60 years ago. The necessary data on the standing trees were recorded and then each tree was cut and dissected with a chain saw. Unlike fire wounds, which are basically of one type, logging wounds are extremely variable, ranging from small bark scrapes to deep cuts. They may occur on any portion of the tree. The type and location of logging wounds are important factors affecting the amounts of internal defect.

Three major questions arise. What amount of defect is associated with logging wounds of different type and location—and with varying age and size of host tree? What is the amount of actual loss at different times in the future that one would expect from such wounds? How can the damage resulting from these wounds be prevented or lessened?

Before such answers can be obtained, many perplexing questions of a more basic nature must be answered. We need to determine the factors that affect the infection and invasion of wounds by wood-degrading and wood-deteriorating organisms. What associations, competitive or stimulative, develop between them and the host tree that influence the processes of discoloration and decay? What is the physiology of the organisms involved? The basic normal physiology of most of these organisms —host tree species included—remains to be known before we can adequately determine the processes involved in complex disease situations.

As a result of our wound study we now have some information on the succession of fungi that infect wounds, the pattern of decays and discolorations in living trees, the association of organisms in living trees, and the factors that affect infection and invasion. However, it is increasingly obvious that our probing must go deeper if it is to explain the basic principles of the decay and discoloration processes in living trees.

BASAL CANKERS OF WHITE PINE

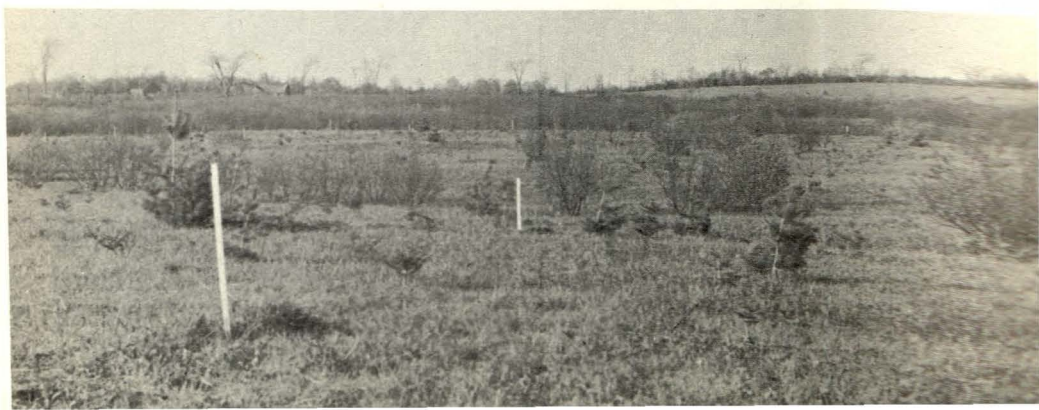
Research continues on a serious basal canker of white pine. The widespread occurrence of this disease in young stands planted on abandoned farm lands in the Tug Hill region of north-central New York has prompted considerable speculation about whether the planting of white pine should be continued.

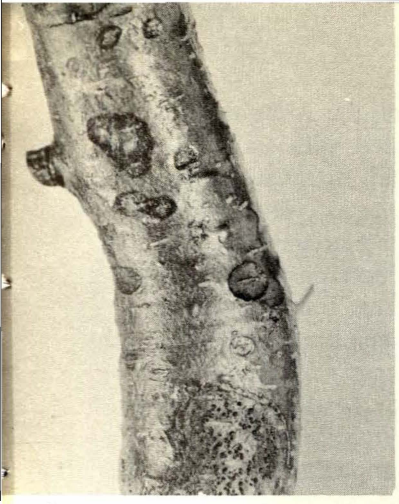
Our investigations of this disease began in 1961, when a species of *Fusarium,* isolated from a typical canker from Tug Hill, incited similar cankers following inoculation of seedlings in the greenhouse and later in the field. Since that time many other fungi have been isolated, and a number of these also have incited cankers in inoculation trials of field-grown seedlings.

The appearance of the cankers and their restriction to the basal portion of the stem suggested that ants might be involved. How-

An opening in a 15-yea old white pine plantir where damage had o curred around two a mounds (indicated b stakes). The dead ar dying trees and several the still green trees in th plot have severe bas cankers.

Each of these stakes locates an ant mound containing active colonies of Formica fusca. Such concentrations of mounds are common on the Tug Hill plateau of northeastern New York. White pine seedlings have been planted about these mounds to see if damage will follow.

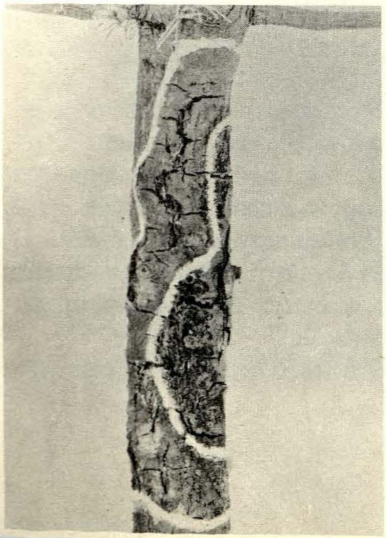




Initial damage on a 5-year-old white pine seedling growing 3 feet from an ant mound. The sunken, reddish cankers develop first about lenticels. In young trees a coalescence of many such spot cankers may result in the girdling and subsequent death of the tree. Many fungi colonize these necrotic areas.

This white pine tree, photographed in May 1963, has an incipient canker resulting from an inoculation with Fusarium sp. in October 1962. This fungus has been re-isolated from such cankers as much as 15 months after inoculation.

This cankered seedling was growing within 8 feet of an ant mound. The canker was delineated in June 1963 (inner white line) and then again in October 1963 (outer white line). During this 4-month period the canker enlarged sufficiently to girdle and kill the tree.



Severe damage to a 25- to 30-year-old tree. The marked swelling above the constricting canker, and the roughened bark of the distorted base, are typical of the disease on older trees.

ever, mounds of *Formica exsectoides* Forel, the Allegheny mound-building ant (the species usually associated with such damage), were found but rarely. On the other hand, many mounds of another Formicine ant species, *Formica fusca* L., were observed in areas where damage was occurring or had occurred.

Studies to date have been designed to determine the respective roles of this ant species and of the various fungi isolated from the cankers. Considerable evidence has been obtained that implicates ants both as the initiators of cankers and as the primary agents responsible for the death of many small trees. Likewise, much evidence has been obtained that implicates fungi as important secondary agents. The fungi apparently colonize the necrotic lesions produced by toxic ant secretions and then, dependent on the pathogenicity of the fungus species involved, may encroach upon the adjacent living bark tissue. By this means, trees may be injured and killed long after their bark becomes resistant to ant damage.

FOMES ANNOSUS ROOT ROT

Studies on the use of soil fumigants to control the underground spread of *Fomes annosus* root rot were continued. Early results are encouraging in that (1) living roots of red pine can be killed quickly in a regulated manner; (2) in most instances, *F. annosus* can be eradicated from roots already severely infected; and (3) fumigated roots, killed either by the fumigants or previously by *F. annosus,* usually become colonized rapidly by soil-borne saprophytes.

An experiment is being initiated to determine the effectiveness of inoculating fumigation-killed root systems with *Peniophora gigantea,* a wood-rotting fungus known to be a strong competitor of *F. annosus.* Because *P. gigantea*—which occurs mainly on dead woody matter—does compete so strongly with *F. annosus,* it might serve to prevent the spread of *F. annosus.*

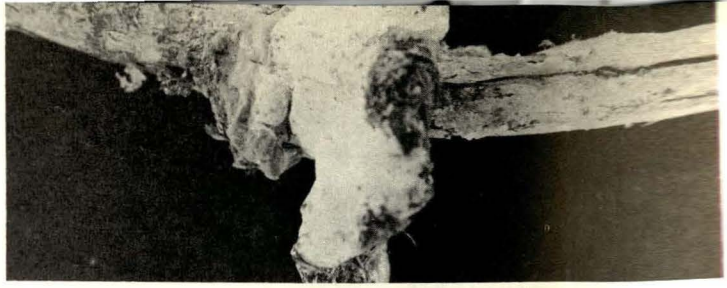
Control of *F. annosus* by stump treatments continues to be an important part of our research. Creosote provides some protection, as evidenced by the reduction of *F. annosus* invasions into newly-cut stumps; but the protection is incomplete. Some creosoted stumps do become infected. Preliminary results of tests in planted loblolly pine on the Eastern Shore of Maryland indicate, after 2 years, that while creosote is better than no treatment, urea is even more effective than creosote.

Dead standing trees, and stumps formed when dead trees are

cut, are not as susceptible to *F. annosus* as stumps formed by cutting live trees. Red pines in the Northeast and loblolly pines on the Eastern Shore killed either by sodium arsenite poison or by suppression have not become infected by the fungus. Attempts to use 2,4,5-T as the poisoning agent were disappointing. *F. annosus* infected 2,4,5-T poisoned trees and even fruited at the site where this material was applied. Besides, the slow-killing action of 2,4,5-T encourages bark-beetle infestations and may, in fact, be related to the relatively high number of *F. annosus* infections found in the poisoned-tree plots.

Some unusual hosts for *F. annosus* were discovered in the course of our studies in Maryland. In 1962 and 1963 single *F. annosus* infections were found on small stumps of sweetgum (*Liquidambar styraciflа*). In 1963 *F. annosus* was found fruiting on poison ivy (*Rhus radicans* L.) and on trumpet vine or trumpet creeper (*Campsis radicans* L.). These are new host records insofar as we can tell from our collection records and the available literature. Whenever we have found *F. annosus* fruiting on a nonconifer host, there has been an infected conifer host close by. It may be, therefore, that infection of nonconifer hosts occurs by means of mycelial contact rather than through air-borne spores.

Fomes annosus **fruiting on poison ivy—an unusual host for this fungus. Pocomoke State Forest, Maryland, November 1963.**



Fomes annosus fruiting on trumpet vine (Campsis radicans L.) Seem. This is believed to be the first time that this fungus has been reported on this host. Pocomoke State Forest, Maryland, November 1963.

CHESTNUT BLIGHT

An article by J. C. Furnas in the April 1963 READER'S DIGEST entitled *They are Bringing Back the Chestnut,* has resulted in our receiving more than 700 letters of inquiry from 41 states and from Canada, Japan, Mexico, and Venezuela. More than 50 American chestnut trees (8 inches d.b.h. and over) within the botanical range of the species will be included in the 1964 screening-for-blight-resistance test.

This fall 12 of the 15 hybrid chestnut test plots established from 1947 to 1955 were inspected. On each d.b.h., height, and other significant data were recorded for the 25 best trees. The largest, blight-free, forest-type hybrid—B26: #3146 USDA—is in a plot near Carterville, Illinois. It is an American X Chinese backcrossed on to an American by R. B. Clapper in 1946. After 17 growing seasons, this tree measured 7.3 inches d.b.h. and 45 feet in height—an increase of 0.43 inch d.b.h. per year, and a height of nearly 2 feet 8 inches per year. It apparently has a high degree of resistance, as chestnut blight is present in the plot.

MISCELLANEOUS

Work continues on several other disease problems. Survey field work on ash dieback in six states of the Northeast has been completed and the data are being analyzed in cooperation with Region 7. An inspection of the maple decline problem in New England and New York was made this fall, and a report has been prepared. Studies of decays in branch stubs and pruning wounds are under way. Information is being gathered on the rate of heartrot development in several commercial tree species of the Northeast.

FOREST ECONOMICS

FOREST-economics research continues to gain acceptance as one basis for forest land-management decisions. Private parties seek guidance in choosing among alternative investment opportunities. Those who share in the growth of our economy are aware of the benefits of efficient allocation of funds. Those landowners and managers whose place in the economy is not so well assured are pressed to use their scarce resources as wisely as possible.

Public agencies also have increased their demand for economic research results. As the demand for their services increases, the agencies must make efficient allocations of their funds. Public forestry agencies are participating in Rural Area Development activities, not only in the search for new or expanded timber industries, but also for non-timber forest resource investments such as recreation and wildlife management.

All of this is reflected in new or stepped-up activities in our forest-economics research.

GOVERNMENT FORESTRY PROGRAMS

Small Woodland Management

This project was recently reactivated. During the past year major emphasis was placed on development of a problem analysis for one part — economic research for more effective assistance to woodland owners. This analysis suggested seven potential areas of research. One deals with dynamic aspects of small woodland ownership. Three research areas deal with the economics of small woodland management. And three others deal with the economics of public and private forestry-assistance programs.

Dynamic aspects of small woodland ownership. — The purpose of research in this area is to provide background information that will be useful in planning shifts in research related to forestry programs and to determine the overall level of program effort that should be devoted to small woodlands. Management decisions of small woodland owners are made within a general framework of economic conditions; of particular importance here are the demand and supply conditions for various kinds of timber

products. Identifying these conditions and defining changes taking place will help to provide a general picture of the markets in which products of small woodlands are bought and sold.

Economics of small woodland management.—The three subareas of research on the economics of small woodland management are: (1) objectives and restraints that influence management by owners of small tracts; (2) efficiency of timber production on small tracts; and (3) competitive strength of owners of small tracts in marketing timber products.

Owners of small woodlands conduct their timber-growing and marketing operations within a particular set of restraints. They also have a set of objectives that might be quite different from those of owners of large industrial timber holdings or for public forests. To be of use to the small woodland owner, information must be presented in a form consistent with the owner's objectives and restraints. To identify these objectives and restraints, and the economic framework within which they are important, is the first step for research.

Two of the probable restraints placed on managers of small woodlands are related to the size of operation. It seems likely that timber-management and harvesting costs are higher on very small tracts than on very large tracts, and that owners of small tracts of timber encounter marketing problems due to the small amounts of products being offered for sale. Tests of the hypotheses designed to identify diseconomies of scale is suggested as a suitable area for research.

Economics of forestry-assistance programs.—The other major area of research in small woodlands, that dealing with the economics of public and private forestry-assistance programs, can also be broken down into three separate research segments. This suggested breakdown is based on three levels of program administration, each of which makes a particular kind of decision.

For example, broad decisions to provide forestry assistance in the form of cost-sharing programs or technical advice are made basically at the federal level. At this level decisions are made as to the types of public assistance to be offered, the institutional forms through which this assistance will be offered, and the allocation of funds among states.

The specification of forestry practices to be emphasized, the stand conditions towards which the practices will be directed, and the allocation of funds among geographic units within the state, are made at the state level. Finally, at the district administrators'

level, choices are made among types of owners at which forestry-assistance programs will be directed.

Each of these three levels provides a separate area for research because the constraints upon the decision level, the data requirements, and the criteria on which choices are made are different at each level.

Other Government Programs

Areas other than small woodland ownerships have also been explored. A case study was made of forest-management decisions on the Elk State Forest in North-Central Pennsylvania, one of the forests managed by the Pennsylvania Department of Forests and Waters. This study attempted to trace the usefulness and limitations of economic analysis as a guide to timber management. In so doing it built on an earlier analysis of major timber-management opportunities in Pennsylvania, by viewing this analysis through the eyes of a perceptive forest manager. The case study asked where and how the earlier analysis had been useful and where and how it had fallen short.

The major conclusion of the study was that limited economic analysis is useful in determining how to spend a given budget, but is less useful in determining how big that budget should be.

ECONOMICS OF TIMBER-GROWING

Scope of Research

Research in this project is largely applied in nature and has as its main purpose to evaluate and compare the efficiency of various methods of growing timber in the Northeast. Some studies evaluate and compare various forest practices used in a particular forest type, or examine different intensities of a single practice. Other studies may deal with different forms of ownership, different methods of financing and organizing management activities, or different locations within the region—all with an eye to discovering how production efficiency is affected by these institutional factors. A third sort of study evaluates the impact of external circumstances on timber-growing activities. What do timber growers do when prices change, when new subsidies become available or old ones are withdrawn, when tax laws change, and so forth?

All these studies are designed to lead to timber-management guides of various sorts, guides that practicing foresters and tim-

berland owners can use in developing more efficient management programs for their timberlands.

Occasionally, research of a more fundamental nature is required to provide the basis for better management guides. For example, during the past few years work has been carried on in developing a new method of evaluating timber-management activities: a method that allows the analyst to determine the effect of imperfect information and uncertainties about future growth and markets on his ability to single out the best management alternatives.

Economic Guides

At the more applied level, research has been carried on in developing economic guides for white pine management and pest-control activities. Work in both these areas has continued during 1963, and several new studies have been begun. One of these new studies deals with management of our eastern hardwoods.

Probably the most frequent type of timber-management decision is whether to retain a salable tree, or group of trees, for an additional period of growth. Economic considerations usually play an important part in these choices; so economic-maturity guides have been developed for some timber species to help managers determine when a tree can no longer be profitably retained.

Economic-maturity guides are an adjunct to other decision-making procedures in the total task of timber-management planning. Choices of management goal, product objectives, silvicultural system, and method of yield regulation must all be made before harvest and treatment choices among individual trees becomes a concern; and the application of economic-maturity guides may depend on these decisions. Thus effective use of economic-maturity guides depends on a reasonably complete and consistent process of overall management planning.

The manager's problem is that he is faced with a complex series of interrelated choice problems, and he frequently has limited information upon which to base his decisions. This new study is meant to provide the manager of eastern hardwoods with two types of planning aids: (1) a general framework for timber-management planning that suggests an orderly and consistent decision-making process; and (2) an economic-maturity guide for important hardwood species that will provide the information he needs to make one of his most frequent management decisions.

This study is still in the planning stage, and it is not easy to predict how well the research will turn out. But we feel that this

study has real possibilities and can make a significant contribution to more efficient hardwood management in the region.

Other Accomplishments

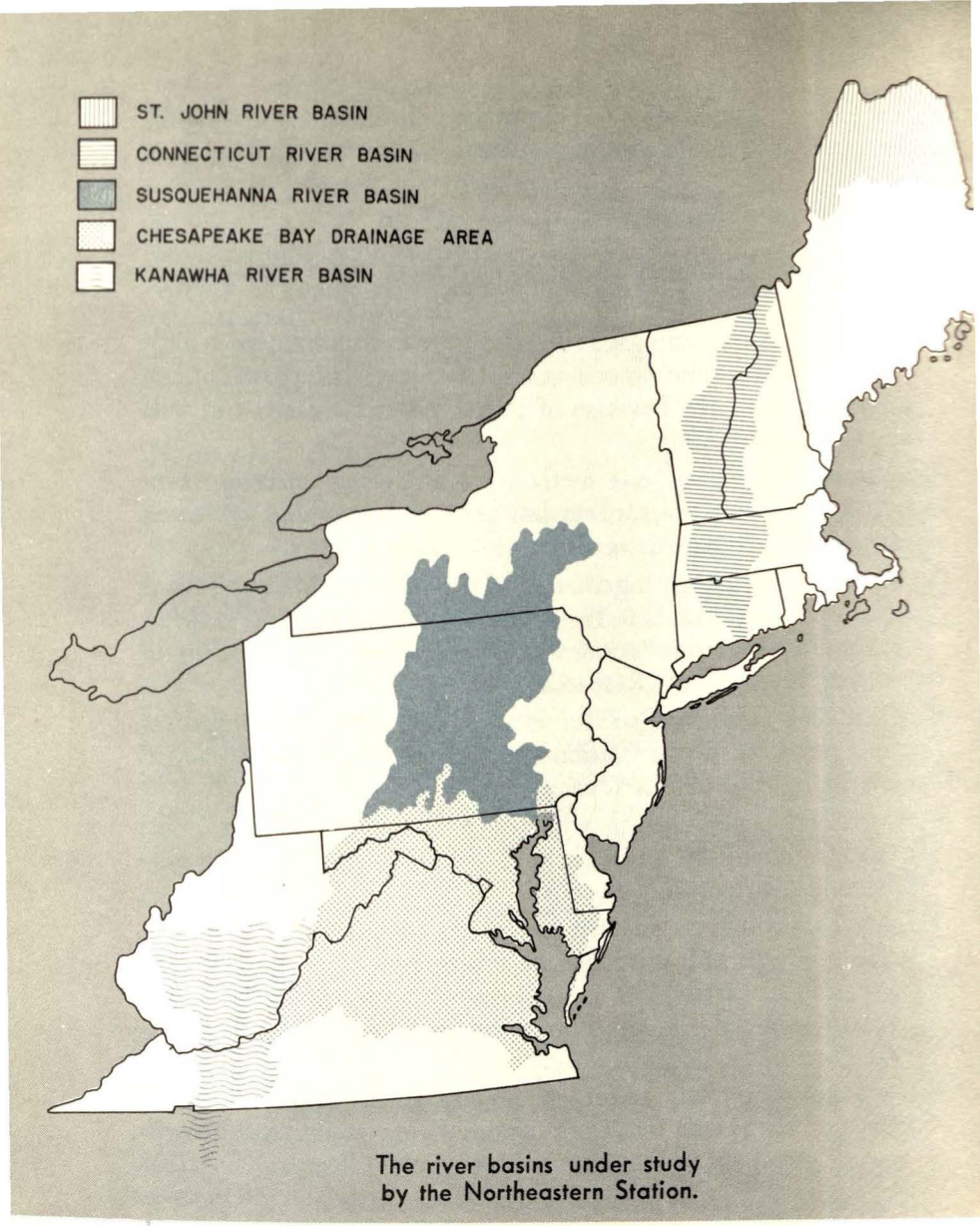
Other accomplishments in the economics of timber-growing in 1963 include:

- A comprehensive publication treating the evaluation and scheduling of white-pine weevil control has been prepared in cooperation with our Division of Forest Insect Research and will appear early in 1964.
- A bulletin outlining one method for analyzing uncertain timber-management investments has been prepared and reviewed and is now being made ready for publication.
- A paper that brings together in one source much of the mensurational data available for white pine was begun and is being carried toward completion with the help of our Division of Timber Management Research.
- A manual of procedures for evaluating timber-stand-improvement practices on the National Forests has been drafted and is now being reviewed in Washington.
- A general paper dealing with the relationship between forest practice, biological research, and economic analysis was published in the *Journal of Forestry.*
- Data collection and analysis have been completed for a region-wide study of the incidence of blister rust infection in white pine stands, carried out in cooperation with state forest pest-control agencies and the Forest Service's Division of Cooperative Forest Pest Control.
- Data collection has begun on a joint study dealing with the effect of hardwood overstory conditions on white pine growth, being carried out by our Timber Management Research Division.

OTHER ECONOMICS ACTIVITIES

River-Basin Studies

In addition to our regular research activities, we are cooperating with other Department of Agriculture agencies in preparing economic base surveys on the agriculture sector for comprehensive river-basin studies. We prepare projections of physical production and employment in the basic forest industries for each of several river basins in the Northeast. The projection of production of



The river basins under study by the Northeastern Station.

timber products is analyzed in terms of likely changes in the timber resource.

Overall responsibility for preparation of comprehensive river-basin studies lies with the Corps of Engineers and the Department of Health, Education, and Welfare. We are cooperating by providing economic base surveys for the Connecticut and St. John river basins in New England for the Corps of Engineers; for the

Susquehanna River basin and Chesapeake Bay drainage for the Department of Health, Education, and Welfare and the Corps of Engineers; and for the Kanawha River basin for the Corps of Engineers.

Reports

The President's Appalachian Regional Commission is preparing a major report for a comprehensive program to raise the economy of that region to the general level for the Nation. The Forest Service helped draft sections on proposed forestry programs. We prepared the section on the timber industries in Appalachia and suggested measures for overcoming obstacles to added development of the timber-based industries.

A report compiling forest-survey statistics for the Northeastern States, together with certain economic data relating to timber production and primary timber processing, has been drafted.

FOREST SURVEY

ADEQUATE information about the timber resource is one prerequisite for decision-making at all levels — national, regional, state, and local. At the national level, periodic forest-survey projections of supply and demand are useful in formulating timber policy for the Nation. Since most of the basic data are gathered state by state, our forest survey helps planners in industry, at county seats, at state capitols, and in regional groups. At the more local levels, interest is mostly in present and prospective timber supply, less in product demand. During the year, forest-survey output continued to meet the demands of several groups of data consumers.

In the first half of 1963 much of our effort went into the compilation and preparation of tables for each of our states and for the New England and Middle Atlantic regions. This recent information on present and prospective timber supply will provide guide lines for local evaluations of industrial opportunities. It will also provide a major part of the basic data and information needed for national program planning.

RESURVEY OF WEST VIRGINIA

West Virginia is the first state in our territory for which forest area and timber volume statistics have been computed on a high-speed electronic computer. For sampling and data-reporting purposes, the State was divided into four geographical strata: (1) National forest land; (2) a northeastern unit of 19 counties; (3) a southern unit of 14 counties; and (4) a northwestern unit of 22 counties.

The computer program produced printed output for each geographic stratum, giving us the first 27 national standard tables. For each national standard table for forest area and timber volume, both totals and variances were printed out. Every cell in every table, each subtotal, and the grand total had computed sampling errors. An interesting and yet not unexpected result was that some areas or volumes of about equal amounts had sampling errors that differed considerably from each other.

The computer program used stratum means and variances to compute area and volume statistics for each county in the stratum. For each county, we have the following acreage figures: (1) commercial forest land; (2) sawtimber stands, poletimber stands, and other stands; and (3) five major forest type groups. We also have growing-stock and sawtimber volume by: (1) stand-size class and (2) species and species groups. For each statistic of area and volume, the corresponding sampling error was printed out, in percent.

The results to be published in 1964 in the timber resource report for West Virginia show that three-fourths of the land area in the State is now covered by forest. Commercial forest land totals 11,389,000 acres. One-half of this area is in sawtimber stands. The oak-hickory forest type covers two-thirds of the commercial forest-land area.

Growing stock amounts to 11,060 million cubic feet. Sixty percent of this is in sawtimber-size trees. Hardwood species account for 95 percent of the total volume.

Sawtimber volume amounts to nearly 29 billion board feet. One-fifth of the volume is in white oak and northern red oak. Other oaks make up 23 percent. Yellow-poplar makes up 10 percent and hickory 9 percent. Ten percent of the hardwood sawtimber volume was made up of grade 1 standard lumber logs, 20 percent in grade 2, 45 percent in grade 3, and the remaining 25 percent was classified as tie and timber logs.

More wood is being grown than is cut—370 million cubic feet

versus 120. Ingrowth, however, made up 48 percent of total growth. This implies that the average timber stand in the State is young and vigorous.

RESURVEY OF PENNSYLVANIA

This resurvey has progressed in excellent style. The Pennsylvania Department of Forest and Waters continued with the cooperative inventory on state forests and completed all field work on about 1.8 million acres of forest land. A training session involving approximately 50 people was conducted for Station and state survey crews. Plot data and information have been taken so that the compilations can be used by both the State and by our forest survey. Cooperative inventories such as this are not only of mutual benefit but prevent duplication of much costly inventory work.

Our resurvey of Pennsylvania was also greatly aided by an Area Redevelopment Administration grant for intensifying the regular forest survey. This will provide reliable local resource data and information by individual counties or by small groups of counties. These data will be used in planning the expansion or development of forest industries. The ARA financing will provide additional aerial photo plots and 500 field plots, as well as covering the added costs of data compilation.

OTHER SURVEY ACTIVITIES

New air photos for the two western counties of Maryland were received, and field work in this area completed the resurvey of the State. Data are now being compiled and a report on the State's timber resources will be prepared in 1964.

Basic timber-inventory data were compiled for a Forest Service report on timber in Appalachia. Numerous requests were filled for inventory data for specific counties and groups of counties—requests from timber industries, consulting foresters, management consultant firms, and state foresters. Many ARA proposals for expansion of existing timber industries or for new firms were screened for adequacy of timber supplies.

Plans for 1964 include the completion of all photo interpretation and field work for the Pennsylvania resurvey and also a start will be made on the resurvey of Vermont.

PRODUCTS MARKETING

THE demand for the results of marketing research is increasing. It comes from many trends in the national economy, which are felt throughout the Northeast. Competition from materials that are substitutes for wood accelerates. As awareness grows that not even the traditional markets are secure, prudent producers of wood products are looking to marketing research for help. The threat to markets and the squeeze on profit margins feeds back to interest in efficient production, both in the woods and at the factory.

An organizational change has been made in our program of marketing research. Early in the year the marketing of forest products was dropped as a line project at Upper Darby, and all responsibility for marketing research was shifted to our new Forest Products Marketing Laboratory at Princeton, West Virginia. Prior to the transfer, some marketing research work already under way was concluded at Upper Darby.

UPPER DARBY

Northeastern Regional Marketing Project

One major piece of work in marketing research was completed in cooperation with six agricultural experiment stations in the Northeast that participated in the Northeastern Regional Marketing Project NEM-24; the regional report on phase II of this project was published in June. This publication described lumber purchases by industrial users of lumber in Maine, New Hampshire, Vermont, Massachusetts, Pennsylvania, and West Virginia. The study showed that, in addition to their normal marketing functions, market intermediaries play an important role in upgrading the lumber product. It also showed that a significant portion of the industrial users of lumber have purchasing problems, particularly problems associated with the failure of purchased lumber to conform to specifications.

One more phase, III, remains to be completed for the NEM-24 project. The phase III report, expected in 1964, will describe lumber purchases by non-industrial users of lumber. With the completion of this phase, the two marketing projects in the Northeast,

NEM-6 and NEM-24, will have succeeded in describing the marketing chain for stumpage purchased at sawmills in the Northeast and for lumber sold by Northeastern sawmills and purchased by northeastern lumber buyers. Both projects provided a wealth of descriptive material concerning marketing practices and products. Participation in these projects by our Division of Forest Economics Research was limited largely to the planning and writing phases; the cooperating experiment stations conducted the data collection and analysis phases of the projects, in addition to their work in planning and writing.

West Virginia Industrial-Opportunity Project

Among the research formerly included under the Upper Darby marketing project are the West Virginia industrial-opportunity studies now being carried to completion. Two major publications were planned. The results of the first, *The Location Decision for Wood-Using Industries in the Northern Appalachians,* published in 1963, were outlined in our *1962 Annual Report.* The second, *Timber Industry Opportunities in West Virginia,* will present an economic evaluation of the relative suitability of five areas in West Virginia for location of various types of wood-using plants. This report, now in review draft, indicates the following:

- Of five selected locations — Beckley, Elkins, Huntington, Parkersburg, and Richwood — Richwood and Elkins are the best for the lumber industry. Elkins is best for the particle-board industry, Parkersburg for the woodpulp industry, and Huntington for the furniture industry.
- All of the areas have some obstacles to further industrial development when compared with competing areas. For the lumber industry, high logging and transportation costs are most important; lack of a concentrated supply of softwood timber is important for both the particle-board and woodpulp industry; uncertainty regarding waste-disposal requirements is important for the woodpulp industry; and lack of skilled labor is of particular importance for the furniture industry.
- Some of these obstacles can be overcome, both through action programs and through research programs. For example, high logging costs could be lowered through successful research designed to develop equipment and methods especially suited to the mountainous terrain of the Appalachian Region. Action programs might also be successful to reduce uncertainty about

waste-disposal requirements for the pulp industry and to provide trained labor for the furniture industry.

One other study conducted as a part of the West Virginia industrial-opportunities project was completed and published in 1963. This was a survey of sawmill residues and lumber as raw materials for wood-using industries in West Virginia. It presented information about the quantities of lumber and residues available in four selected areas of West Virignia.

FOREST PRODUCTS MARKETING LABORATORY

The year 1963 brought many changes and improvements in the physical facilities, staff, and research program of our Forest Products Marketing Laboratory. It was a period when the objectives and program of the Laboratory gained widespread understanding and approval by the forest industry. This acceptance was evidenced by numerous offers of cooperation and assistance—including financial aid—being extended to the Laboratory by individual concerns and associations. Some offers have already been utilized; others will be taken up later when the need arises.

Although the Laboratory has not yet published any research results, it has made considerable progress during the year in staffing and in planning and initiating studies. The Laboratory will be host to the Northeastern Forestry Research Advisory Committee at its annual meeting on June 18-20, 1964.

Physical Facilities

The Laboratory's new office-headquarters building was occupied in late October and was dedicated on November 12, when U. S. Senator Robert C. Byrd of West Virginia delivered the dedication address to an overflow crowd of more than 300 people. The new facility was constructed at a total cost of approximately $450,000 for design, construction, and development of site and facilities. It will provide offices and related facilities for 20 to 25 scientists and an equal number of clerks, technicians, and other supporting personnel.

Planning was completed and construction was nearly finished on a second large building, the Laboratory's methods-testing plant. This building will house much of the Laboratory's physical research in the development and testing of improved methods to manufacture, use, and market wood and wood products. Except

for concrete foundations and the floor in the test room, wood is being used almost exclusively in the construction of this building. This includes the use of 64-foot-long wooden roof trusses over the 10,000-square-foot test room, all-wood exterior and interior walls, and combination wood and cement roof-decking material. Total cost for the building, including site and utility development, will be about $200,000.

Personnel

An active recruiting program was carried on during the last 6 months of the year. Eighteen people were on the staff at year end, including seven scientists, three technicians, five clerical and administrative people, and three maintenance and custodial employees. Five additional scientists will be added to the staff as rapidly as possible, to complete our plans for employing a total of 12 scientists and 11 supporting personnel during the current fiscal year.

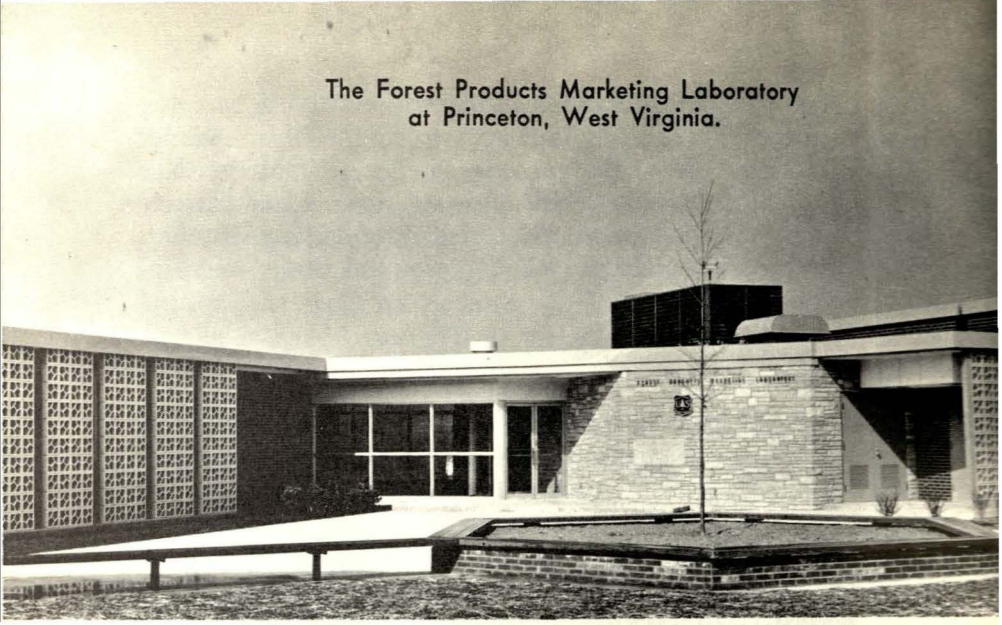
Program Formulation

The scope and nature of the Laboratory's overall program of forest products marketing research was revised and expanded during the year and is now somewhat different than reported in last year's *Annual Report.* The objective remains about the same: to develop information leading to the improvement of the competitive position—and thereby the marketability and total use—of wood and wood products. The program will include studies of factors affecting the preparation, sale, distribution, and use of forest products for industrial or consumer use. The ultimate goal is to develop knowledge leading to the expansion of timber-based industries and a corresponding increase in employment opportunities. The revised Laboratory program is now divided into four lines or fields of research:

1. **Marketing primary forest products.** — Research directed toward improving the value and marketability of sawlogs, pulpwood, veneer bolts, and other primary forest products from both commercial-size and smaller woodlots. Research in this field will be divided into four general areas of investigation: resource analysis, harvesting operations, assembly and distribution, and small woodland products.

2. **Marketing of primary wood manufactures.**—This area of investigation will be aimed at improving the marketability and

The Forest Products Marketing Laboratory at Princeton, West Virginia.



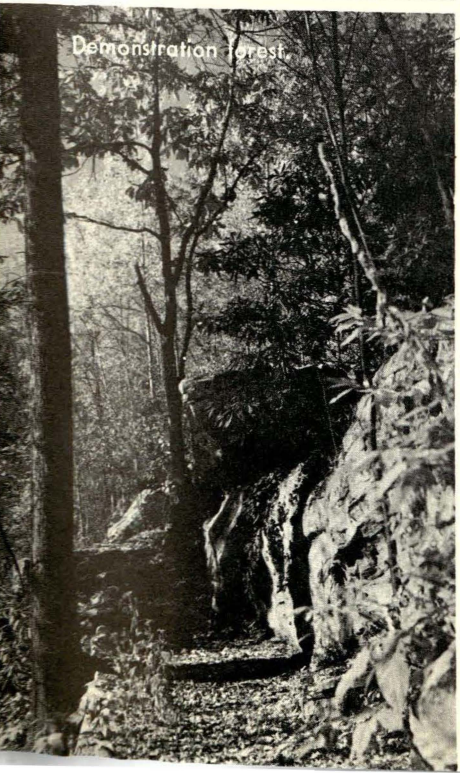
utility of lumber, veneer, composition board, residue products, and other primary wood manufactures. The problem will be attacked through improved manufacturing processes, increased product quality, more competitive pricing, better distribution and merchandising, and a better understanding and correlation of both resources and market outlets.

3. **Marketing secondary wood product manufactures.**—This is a program of research to improve the competitive position and marketability of flooring, furniture, plywood, and other secondary wood manufactures. This goal can be reached by developing new and improved products, new or more efficient manufacturing processes, better distribution and merchandising methods, and better utilization of the available wood materials.

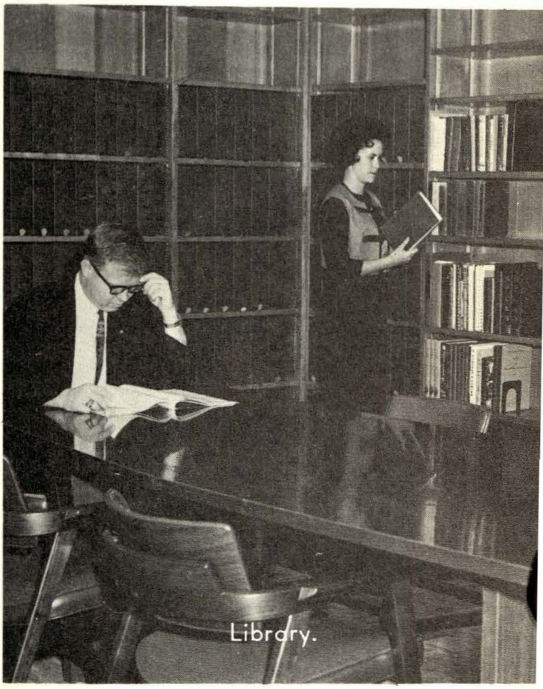
4. **Marketing wood for construction.** — A program of research directed toward development of ways to increase the marketability and use of wood in residential construction as well as in industrial, farm, public, and other non-residential building. Measures to be investigated will include the development of improved construction products; better understanding of what consumers want and need; improved building designs and engineering; more satisfactory and more competitively priced wood materials for different construction uses; and improved merchandising and distribution methods.

View from lobby.

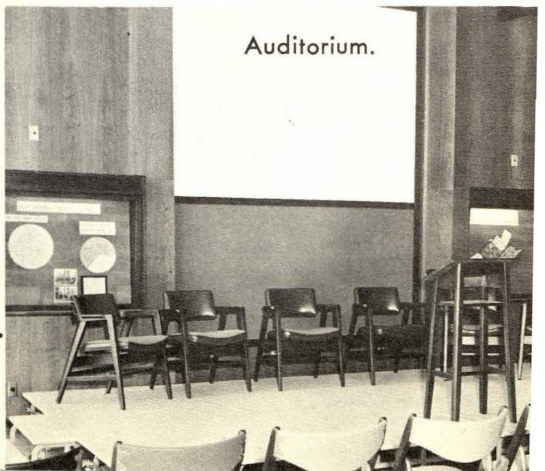
Garage-workshop.



Demonstration forest.



Library.



Auditorium.

Wood is featured in the design and construction of the Laboratory's methods-testing plant, now nearing completion.

Workmen assembling the 64-foot-long wooden roof trusses for the test room.

Marketing Secondary Wood Product Manufactures

Research in secondary wood-product manufactures was concentrated during the year on the problem of marketing hardwood flooring. The initial investigation in this field is being conducted in cooperation with the four associations concerned with promoting wood flooring: the National Oak Flooring Manufacturers Association, the Maple Flooring Manufacturers Association, the Hardwood Plywood Institute, and the American Parquet Association.

Problem analysis of the hardwood flooring market. — A problem analysis of the production and market structure of the hardwood flooring industry was completed during the year. It shows that the manufacture of hardwood flooring utilized approximately one-fifth of all hardwood lumber produced annually from 1959 through 1962. In West Virginia alone, 40 percent of the lumber production was used by the flooring industry in 1960. The hardwood dimension and flooring industry utilizes the most plentiful hard-to-sell grades and species of hardwood lumber and provides employment for more than 25,000 people. Considering the thousands of others engaged in producing the raw material, it is clear that flooring is important to the economy of all hardwood regions, and particularly to the South and the Appalachian Region.

Despite the favorable service record of residential hardwood flooring, the industry is suffering from dwindling markets. Oak flooring shipments have dropped from about 1.2 billion board feet in 1955 to 0.8 billion board feet in 1962 — a 35-percent loss in markets. Oak's share of the potential residential flooring market has dropped from 68 percent in 1955 to 38 percent in 1963. Maple flooring has also lost markets, indicating that wood flooring is also being replaced in industrial and institutional applications.

On the basis of the problem analysis, two research work plans have been completed and are now ready for field-data collection, and a third is being prepared. Each one will attempt to determine and evaluate the factors responsible for the loss of hardwood flooring markets. Brief outlines of the flooring studies follow:

Comparative maintenance costs of residential floors. — The long-run cost as affected by maintenance and wear-life is the true cost of flooring to the homeowner. But aside from cost, the homemaker develops a preference for a certain type of flooring, based on the time and effort that must be spent in maintaining it at a satisfactory appearance level. Manufacturers of competing floor-

ing materials recognize the importance of maintenance in the decisions of builders and homeowners, and are presently waging vigorous advertising campaigns that claim maintenance advantages for non-wood flooring materials. Although apparently based primarily on opinions, not supported by facts, these campaigns seem to contribute to the decline of the wood-flooring markets.

Factual information is needed about the comparative maintenance requirements and long-run costs of the various types of finish flooring materials. Consequently, a study was begun to compare these costs for all of the principal flooring materials. The comparative data will be based on initial installed cost, wear-life, minor maintenance costs, and major maintenance costs.

The study will be conducted in apartment buildings to facilitate data collection. The initial costs of the various types of flooring and the long-run costs based on wear-life will be obtained through personal interviews with the apartment-building owners or managers. The amount of effort and cost required to maintain the various types of flooring at a satisfactory appearance level will be obtained through interviews with a subsample of individual apartment dwellers. The findings should present a true picture of the long-run cost and satisfaction from different kinds of flooring to the owner and homemaker.

Factors restricting use of wood flooring in slab construction. —A second study is under way to deterimne why hardwood flooring is little used nowadays on concrete slabs. In 1950 the average single family home utilized 940 board feet of finish wood flooring. By 1959 this figure had dropped to 650 board feet. During the same period, the percentage of single-family homes built on concrete slabs increased from less than 10 percent to 43 percent. This amounts to a one-third increase in the percentage of single-family houses built on concrete slabs — where little hardwood flooring is used. The increasing use of concrete-slab subfloors in single and multi-family housing is probably the most important factor restricting the use of wood flooring.

The study of this problem will attempt to determine the existing methods for installing wood flooring on concrete slabs; to evaluate these methods as to the ease and cost of installation and acceptabiilty of performance; to identify and evaluate factors limiting the further use of wood flooring on slabs; and to determine corrective actions.

The study is planned for three phases. The first will be conducted by interviewing flooring contractors or builders to determine their methods and experiences of installing wood flooring

on concrete slabs. In a second phase we will interview homeowners who have homes with wood flooring installed on a concrete slab to evaluate the performance of the floor after extended use. In the third phase we will interview floor contractors who do not regularly install wood flooring on slabs in an attempt to find out why they do not.

Comparative maintenance costs of floors in public schools. — Public schools were until recently one of the largest users of hardwood flooring, and even now they are one of the principal markets for hard maple flooring. But during the last decade other non-wood materials have replaced wood flooring in many school rooms. Much of this loss is attributed to the widespread belief that non-wood flooring materials require less everyday care and maintenance and have better service life than wood flooring.

This study will determine the comparative initial cost, maintenance costs, and repair and replacement costs for different floor materials in public schools. Information will be collected and analyzed to compare different floor materials on the basis of different rooms and uses (classrooms, auditoriums, hallways, etc.) for schools of different sizes and number of pupils, and over periods of time ranging from 3 to 15 years or more. Sampling will be carried out in a number of schools selected at random from school systems of a number of large eastern cities.

Primary Wood Manufacturers

The sawmill industry is the largest and most important wood-based industry in the Appalachian Region, both in number of employees and value of its products. Consequently a large portion of our research program on primary wood manufactures deals with factors that affect the marketing of products from the 4,500 sawmills and planing mills in the states wholly or partially within the Appalachian Region. Some 500 of these are in West Virginia. Three studies dealing with lumber marketing were begun or planned during 1963, and a substantial amount of technical assistance was given to individual members of the lumber industry.

Evaluation of commercial air-drying practices. — The Forest Products Laboratory estimates that, of the lumber marketed, the U. S. lumber industry loses $8 to $11 per 1,000 board feet through drying degrade and other lumber waste. If the Appalachian Region suffers a proportionate share of this loss, it would amount to $50 million annually. This would also have a decidedly limiting effect on the marketability and value of Appala-

chian hardwood lumber. To evaluate this problem, a study was designed to determine the prevailing air-seasoning practices in the Appalachian Region, and to evaluate these practices with regard to their effect on the condition and marketability of hardwood lumber.

Approximately 225,000 board feet of red oak and yellow-poplar lumber is being studied at 15 randomly selected sawmills in the southern Appalachian Region. Approximately half the lumber is from summer production and half from winter production. The lumber is inspected by NHLA rules when air-seasoned, and both seasoning degrade and variation in moisture content are determined.

The study is now about 40 percent complete. Preliminary results indicate that significant losses occur during the seasoning of red oak, particularly in thick winter-cut stock; but that losses in air-seasoning yellow-poplar from summer production are insignificant. Seasoning practices appear to be affecting the market for red oak but do not appear to have an influence on the market for yellow-poplar. We are considering extending this study to include additional sawmills in the northern Appalachian Region and possibly to include additional species.

Evaluation of a low-temperature lumber dryer.—One of the more serious problems in marketing the products of Appalachian sawmills is the inability of the mills to provide air-dry lumber during the winter months, particularly in the thicker sizes. This problem—in addition to the defects associated with air-seasoning — indicates the need for an improved method for drying green lumber to a moisture content of approximately 20 percent. A study plan has been prepared and a drying unit designed to evaluate the economics of drying hardwoods on a year-round basis in a low-cost, low-temperature dryer that utilizes solar heat and forced-air circulation.

The dryer used in this study will be a privately constructed and owned facility that is designed to maintain a maximum temperature of 100° F. The cost of drying to 20-percent moisture content for the various species and thicknesses, the amount of surface and interior drying defect, and the range of final moisture content for the lumber, will be determined in the study. The results will be evaluated in reference to their effect on the value, marketability, and utility of the lumber.

Evaluation of the physical and economic efficiency of sawmilling practices. — A 40-percent decline in the number of saw-

mills in the last decade has resulted in part from changes in the structure of the lumber market. Lumber prices have remained nearly constant, while production and stumpage costs have increased significantly. The very large and very small mills are disappearing; the remaining medium-size mills are becoming more automated and are increasing utilization of mill residues.

Yet the overall economic status of the industry is still not sound. It is subject to severe fluctuations in markets and returns on investment. A study of the prevailing sawmilling practices is needed to provide knowledge of those production factors that limit the markets for lumber and other mill products, and to point out the factors that cause economic weaknesses in the industry.

The study now being prepared will include a random sample of sawmills of different capacities in all parts of the Appalachian Region. Approximately 2 full days of production will be evaluated, determining the quality of lumber production as compared to the quality of logs sawed. Measurements will also be made of dimensional accuracy and lost production time for each mill. The value of daily production will be determined and compared to the capital investment in the mill, the working capital utilized by the mill, and the manpower utilized in production operations. Particular attention will be given to the manpower and equipment mix and their relative efficiency and productivity. Field work is planned to start early in 1964.

Assistance to primary manufacturers. — Technical assistance on lumber production and marketing problems was given on request to a number of primary processors during the year. In most cases the assistance was provided on a basis that the facilities or operations involved would be available to the Laboratory for research purposes. In other instances the technical assistance provided an opportunity for our Laboratory people to pretest research techniques or study proposals. Examples of this assistance are as follows:

- A design for a new sawmill and lumber-seasoning yard, with special provisions for an advanced method for grading, sorting, stacking, and shipping lumber, was prepared for installation in Doddridge County, W. Va.
- Detailed design for a highly automated lumber concentration yard in Kittanning, Pa. is now in operation and available for Laboratory studies to evaluate the practicality of concentration yards as marketing media for small sawmills. This facility is

essentially the same as the unit previously considered for operation as a research project by the Laboratory.

- Detailed design for a sawmill and mechanized lumber sorting, grading, stacking, and drying facilities as an expansion of an existing treating plant and lumber concentration yard near Spencer, W. Va.
- Developed preliminary information regarding capital, lumber needs, and personnel requirements for a proposed 10,000-square-foot-per-shift edge-glued flooring plant in Garrett County, Md. Construction of this facility is doubtful due to competitive factors.
- Provided a design for an improved lumber-seasoning yard at a Raleigh County, W. Va., concern to permit the company to increase their yard capacity and improve the efficiency and quality of seasoning operations.
- Developed designs for a portable lumber-stack roof to increase efficiency and reduce air-seasoning degrade and for a lumber-shipping shed in Kanawha County, W. Va., including provisions for improved methods of grading, sorting, handling, and packaging.
- Developed and provided a plan for a portable lumber-stacking jig for lift-truck handling of lumber and a design for a semi-automatic lumber sorter to handle the production of an 8,000-board-feet-per-day sawmill in Greenbrier County, W. Va.
- Evaluated production operations of a large sawmill operation in Greenbrier County, W. Va., to determine quality and volume yield of log conversion and to assess overall operational efficiency. This assistance enabled Laboratory scientists to test the procedures planned in the upcoming study of sawmill efficiency.

Marketing Wood for Construction

Research in marketing wood for construction was begun late in the year when one scientist was recruited and assigned to this work. Work is well along on an evaluation of recent developments in the low-profile plenum-floor system for residential construction. The Laboratory is principally interested in determining the opportunities and need for additional research to develop this system sufficiently for general acceptance in residential construction.

Research at Washington State College under National Lumber Manufacturers Association sponsorship indicates that this system

has the potential of competing with concrete-slab construction. The plenum-floor system utilizes wood joists and subflooring and simplifies the use of hardwood flooring. It could have an appreciable effect on wood markets if a large proportion of the present 43 percent of single family houses now being constructed on concrete slabs were converted to this system.

Preliminary planning is also under way to determine the need and opportunities for research by the Laboratory into the problem of sound transmission by hardwood flooring used in multistory apartment buildings.

UTILIZATION IMPROVEMENT

IN GENERAL, 1963 witnessed the continuing adoption of new developments in the wood-using industries of the Northeast and the increased use of wood of all types. There was a general trend in all segments of the industry to invest in new and more efficient equipment to improve product quality and reduce production costs. Markets for furniture, oak flooring, hardwood veneer, and dimension held strong; and the industries continued to be quite healthy. Earlier talk of high taxes, high stumpage prices, and continuing low price for products had presaged a high mortality among producers in the Northeast; but this did not materialize. A few of the smaller sawmills did close their doors, though.

Under the stimulus of the Rural Areas Development program and an increasing public interest in the wood-using industries, and with financial assistance from a number of sources, many new industries were started in the region, and numerous plant expansions occurred. This growth involved sawmills, fencing plants, other more or less primary products producers, up to furniture plants.

The pulp and paper industry of the Northeast continued strong, with the reopening of a pulping facility that had closed the previous year. Some producing plants expanded their operations, and other expansions were planned for the future. The production of pulp chips and pulpable sawmill residues continued to increase

throughout the region, and this source of supply is now no doubt a permanent feature of the pulp and paper industry.

The use of dried, graded, and screened sawmill residues for packaging, fur-cleaning, metal-polishing, food-smoking, and tanning increased during this year; and the demand continues high.

The production of particle board increased. Establishment of a new and completely automated plant is in progress. The increasing use of overlay materials of all types continues to expand the use of particle board.

Our Division of Forest Products Utilization Research has been involved in many of these developments, assisting representatives of the industries and development agencies in reviewing plans, applying research results, and planning new studies to obtain information not now available.

TIMBER HARVESTING

Integrated tree-length logging still appears to be the most economical method of operation in the Northeast. The demand for veneer-quality hardwood logs, experimental work with softwood veneer cutting, and an increasing market for graded log material have continued to stimulate this type of logging operation. A representative report of the industry at the ninth Northeastern Loggers' Congress stimulated further interest in this type of logging, for the small operation as well as the large.

The relatively high cost of wheeled log-moving machines now available has restricted their use in small operations. Considerable development work is going on in the Northeast to mechanize logging operations at an investment cost that is feasible for the small operator.

Several purchasers of pulpwood in the Northeast have adopted purchasing practices based on weight instead of volume, and many others are investigating the feasibility of doing this. The Station has supplied considerable information regarding research in this field.

SAWMILLING

More mechanized material-handling units were installed in relatively small sawmills. Those larger sawmills that were developed in the area during the year were all completely mechanized and automated.

Sawmill operators evinced an increasing interest in methods of increasing efficiency of their operations, and we advised various organizations on practical methods of increasing sawmill efficiency. Although many operators are not financially able to install new machinery at this time, it is evident that there is an increasing interest in the economics of material handling, accurate dimension production, machinery maintenance, and more accurate records of the whole operation to be used as a guide toward more efficient production.

The Division answered many requests for research information on the storage of logs, the practicability of waste utilization in the form of charcoal, sawdust, or pulp raw material; the production of stress-graded structural lumber of local species; and the production of graded material for various uses. A survey of new operations showed that many of them are a part of some type of integrated manufacturing operation. Increased efficiency of material recovery is a growing trend in the region.

SEASONING

The continuing development of ultra-high-frequency drying techniques in the area during the past year attracted considerable attention to this process. A series of tests indicates that the available equipment is not feasible for drying large amounts of mixed species in rough lumber of various thicknesses, but is eminently feasible for drying small, standard-size items in large numbers and for drying sample-size material for laboratory or kiln-sample techniques.

Since approximately 40 percent of the lumber now entering manufacturing processes is lost as waste material after it has been seasoned, the concept of in-line drying in the wood industry has been an ever-present dream but is not yet a possibility. The developments in high-frequency drying both here and abroad are rapid, and they may soon be particularly applicable to such in-line drying in some manufacturing industries of the Northeast.

The Division continued to report to the kiln clubs of the region on the latest research techniques for local species. Several problems of discoloration and other drying defects were the subject of cooperative study by the Forest Products Laboratory and the Station.

PULP AND PAPER

The outside storage of northern hardwood pulp chips—particularly beech, birch, and maple—has been increasing. And discolorations occurring during storage have necessitated increased pulp bleaching, which adds to the cost of production. The effects of discolorations on pulp strength are still unknown. But we do know that various pathological, bacteriological, and chemical reactions take place during storage.

The Forest Products Laboratory, the Division, and a cooperator within the region studied the organisms present in an outdoor chip-storage pile of these species and other hardwoods in an effort to determine some of the conditions existing during the storage period. Various pathogens and bacteria were isolated from these stored chips by the Forest Products Laboratory. An extensive study of the outdoor storage of hardwood chips designed to isolate more of these organisms, determine the chemical changes in the wood, and further define interior conditions of the piles is planned for the immediate future.

OTHER WOOD-USE DEVELOPMENTS

The Division cooperated with several organizations on different development studies relative to wood use in the Northeast. Specialty finishes such as neoprene coatings for water-tower use, plastic overlays for exterior wood use, and fiber and plastic laminates with wood received intensive study. Some of the results of this research were reported to the Northeastern Section of the Forest Products Research Society. The continued development of these types of finishing materials seems to indicate a revival of the competitive position of wood for exterior use, and for interior uses where the surface hardness of wood may not be sufficient to warrant its use in natural form.

In accounting systems, the use of high-speed data-processing equipment is gaining wider acceptance in many fields. The wood industry has probably not progressed as rapidly in this area as some other industries, but reports from the region indicate that production facilities with as few as four units can now be successfully operated on a computer accounting system, and considerable savings result from this form of cost control.

An informal cooperative study with The Pennsylvania State University on the anatomy of hemlock shake associated with sapsucker damage has resulted in some interesting observations,

which will be published shortly. The object of this study was to clarify the reasons for the occurrence of shake so that some practical control might be attempted through management of hemlock stands.

The Division is participating in the work of the Hickory Task Force headed up by the Southeastern Forest Experiment Station in an effort to enlarge the knowledge of this species and increase its utilization.

The Division was consulted by numerous other organizations within the Northeast, and some abroad, on such divergent subjects as the correct binder to use in the production of charcoal made from jute in India, the economical production of charcoal in the developing African country, the feasibility of producing particle board from sawmill residue in Malaya, and numerous considerations for local wood-using plants.

OTHER ACTIVITIES

Division personnel continues to be active in affairs of the Forest Products Research Society, the Society of Wood Science and Technology, the Northern Loggers Association, the New England and Keystone Kiln Drying Associations and several other related organizations. We also continued participation in numerous log-grading and sawmill training sessions sponsored by federal, state, and industry organizations throughout the area.

TIMBER QUALITY

THE Northern Softwood Log and Tree Grade Project initiated a series of red and jack pine quality studies on the Chippewa National Forest and Red Lake Indian Reservation in northern Minnesota during the summer of 1963. At present there are no approved log or tree grades for these species. The evaluation of red and jack pine stumpage is further complicated by the practice of marketing several products from these species. From a single tree it is not unusual to cut sawtimber, poles or piling, posts, and pulpwood.

Therefore, besides developing log and tree grades that will reflect lumber values, a secondary objective of the studies will

be to develop tree-value indices or tree grades that will reflect the optimum or multiple-product value of any given tree.

Detailed data on factors affecting quality of poles and piling are recorded for all study trees before and after felling, as well as the optimum product data for each tree before it is actually bucked into sawlog lengths and pulpwood. With such a procedure, each study tree serves a dual purpose: (1) it provides optimum product data and value, and (2) it provides lumber grade-yield data for diagramed logs and trees.

Field work through the sawing phase (green lumber yields) has been completed for 150 red pine and 85 jack pine trees from the Chippewa National Forest. Sawing of an additional sample of 110 red pine trees from the Red Lake Indian Reservation will be completed early in 1964. Additional studies in these species are planned for Maine and Michigan.

A re-evaluation of lumber price relatives of white pine lumber was undertaken during the past year. Because of the erratic behavior of lumber grade prices during the past decade, it appears that, if quality-index values are to be used in log-grade development or appraisal determinations, an annual re-evaluation of price relatives will be necessary. Use of quality-index values (No. 1 and 2 Common = 100) for the 3-year period 1952-55 results now in predicting values as much as 10 percent higher than actual.

Analysis of the Southern Appalachian and Lake States white pine log-grade studies is still incomplete. With the arrival of a log-grade specialist at the Station early in 1964, completion of this analysis can be expected at an early date.

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PUBLICATIONS

in 1963 by staff members and cooperators of the Northeastern Forest Experiment Station, Forest Service, U. S. Dept of Agriculture.

General

Marquis, Ralph W.
1963. **Summary of forest land use conference.** N. Y. State Forest Land Use Conf. 8 pp. Albany.
An urgency is sensed in the need to initiate corrective action programs before it is too late to assure the continued production of materials and services from the forest resource of the Northeast, where an increasing population is placing increasing pressure on timber-producing areas, water supplies, fish and game populations, and recreational facilities.

Marquis, Ralph W.
1963. **Mysteries of federal forest research unveiled.** Amer. Pulpwood Assoc. Tech. Papers October 1963: 5-8 (APA Tech. Paper 63-1: (0.12).).
Discusses the general procedure of program formulation, including limitations imposed by fund appropriations, organization, capability of staff, adequacy of facilities, etc.; and also the flexibility that permits re-orientation to meet new problems, to take advantage of cooperative opportunities, and to adjust to needs for greater depth or breadth in studies.

Northeastern Forest Experiment Station
1963. **Annual report, 1962.** U. S. Forest Serv. Northeast. Forest Expt. Sta., 84 pp., illus. Upper Darby, Pa.
A summary of research activities and accomplishments in forest management, watershed management, forest insects, forest diseases, forest economics, and forest utilization. Annotated list of publications.

Timber Management

*Blum, Barton M.
1963. **Excessive exposure stimulates epicormic branching in young northern hardwoods.** U. S. Forest Serv. Res. Note NE-9, 6 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Information was needed to determine whether the drastic exposure of young northern hardwoods by patch-cutting in adjacent older stands might cause a degrade in potential quality. In a 1-year study, differences in numbers of epicormic branches were found between exposed

*Copies or reprints available from the Northeastern Forest Experiment Station, U. S. Forest Service, 102 Motors Avenue, Upper Darby, Pa.

and unexposed trees, among species, and between 10- and 20-year-old trees. Preliminary results were obtained on the origin of epicormic branches.

Blum, Barton M., and Stanley M. Filip.
1963. **Pointers on how to best weed northern hardwoods.** Forest World 2 (4): 44-47.
Lack of information about techniques and costs is one obstacle to the acceptance of weeding as a common silvicultural practice in young northern hardwood stands. A crop-tree weeding conducted in eighteen 10-year-old patch cuttings on the Bartlett Experimental Forest in New Hampshire provided some information on man-hour requirements and weeding procedures.

*Blum, Barton M., and Stanley M. Filip.
1963. **A demonstration of four intensities of management in northern hardwoods.** U. S. Forest Serv. Res. Paper NE-4, 16 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
To help get research results into practice, demonstrations of various types of cutting practices are often useful. Four intensities of management—light selection, moderate selection, diameter-limit cutting, and liquidation—were applied over a 7-year period to 5-acre demonstration plots on the Bartlett Experimental Forest in New Hampshire. Responses in terms of growth, quality, and regeneration were generally in accord with past experience.

Cunningham, Frank E.
1963. **Research in the sugar bush.** Berkshire Eagle, March 6, illus. Pittsfield, Mass.
Through research, the possibilities for improved sugar bushes are increasing. Better sugar bushes may come about from long-term breeding programs, propagation of superior trees, or—in the immediate future—by favoring the better trees in thinning operations. (Newspaper article.)

Davis, Grant.
1963. **Mine-spoil revegetation research in Pennsylvania—a story of cooperation in action.** Natl. Symposium on Control Coal Mine Drainage Proc.: 58-67. (Pa. Dept. Health Div. Sanitary Engin. Pub. 4.)
The revegetation of mine spoils is one of the most difficult conservation problems in Pennsylvania. The research program in this state has provided encouraging early results as well as an excellent example of federal, state, and private cooperation.

Davis, Grant, and Rex E. Melton.
1963. **Trees for graded strip-mine spoils.** Pa. State Forest School Res. Paper 32, 4 pp.
A large part of the tree-planting effort in Pennsylvania is on bituminous mining spoils. A survey of 7- to 10-year-old plantations indicated that species previously found to grow well on ungraded spoils also did well on graded spoils. Japanese larch, Banks pine, and the timber varieties of Scotch pine were the best conifers for such sites.

Doolittle, Warren T.
1963. **Timber management research programs in the Appalachian area.** Amer. Pulpwood Assoc. Tech. Paper 63-P-2, 4 pp.
Describes the silvicultural research under way at the Northeastern Station's projects at Elkins, W. Va., and Warren, Pa. A greater emphasis is planned for basic research; and an increasing need is evident for multiple-use information.

Doolittle, Warren T.
1963. **Experience in site-evaluation methods for timber production. In Range research methods,** pp. 64-68, U. S. Dept. Agr. Misc. Pub. 940, 172 pp., illus.
Determination of the productive capacity of land should be one of the first steps in developing an intensive timber-management program. The use of site index, indicator plants, and soil-site characteristics for estimating site quality is discussed, and suggestions are offered for future research on site quality for timber production.

*Fenton, Richard H., and Ralph P. Broomall
1963. **Seven-year results in managing a small woodlot in southern Maryland.** U. S. Forest Serv. Res. Note NE-10, 6 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
To provide a basis for recommendations to small woodland owners, data were taken on the costs, returns, and stand development resulting from the management of a pine-hardwood experimental woodland. Results indicated that a modest return to the owner could be realized if he and a helper did the harvesting work; regeneration and stand improvement appeared adequate.

Gabriel, William J.
1963. **Sweet sugar maples wanted.** Natl. Maple Syrup Digest 2(2): 10.
Maple syrup producers are requested to report unusually sweet trees to their local service forester or extension agent. The best trees will be used in breeding superior sugar-producing maples.

*Gibbs, Carter B.
1963. **Field trial of a tree injector in a weeding in West Virginia.** U. S. Forest Serv. Res. Note NE-8, 3 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Injector treatment of small, undesirable stems on a 5-acre plot of mixed mountain hardwoods indicated that sugar maple is difficult to kill, that injector cuts probably should be closely spaced, and that an injector that allows for control over the amount of silvicide per cut might be more effective than the automatic injector that was used.

*Gibbs, Carter B.
1963. **Tree diameter a poor indicator of age in West Virginia hardwoods.** U. S. Forest Serv. Res. Note NE-11, 4 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
For silvicultural purposes, tree diameter is sometimes used as a guide to tree age. Data from unmanaged mountain hardwood stands revealed great variability in the relationship of diameter to age. Thus tree

diameter cannot be used as a reliable indicator of tree age in these stands.

*Hough, Ashbel F.
1963. **Gum spots in black cherry.**
Jour. Forestry 61: 572-579, illus.
Gum spots cause serious degrade in black cherry logs. The *Prunus* miner *(Phytobia pruni)* is mainly responsible, but *Dryocoetes betulae* and climatic factors may also be causes. Suggestions for silvicultural control include: early cultural work; removal of rough, large sprouts in older stands; and establishment of dense new stands on sites zoned to avoid glaze damage.

Hough, Ashbel F.
1963. **What a glaze storm brings.**
Pa. Forests 43(1): 4-5, illus.
Glaze storms may cause severe damage to Allegheny forests in the form of broken or windthrown trees, reduced stand density and growth, and decay. However, because they may recover sufficiently, some damaged trees need not be removed in salvage operations.

Jensen, Victor S.
1962. **History and accomplishments of hardwood management research.** New York Forester 19(1): 1, 3-5.
Reviews the development of forestry research in the beech-birch-maple type of New England, and discusses problems and practices in the regeneration, intermediate treatment, and harvest cutting of stands in this type.

*Leak, William B.
1963. **Calculation of "Q" by the least squares method.**
Jour. Forestry 61: 227-228.
A least-squares method is described for calculating "q", the average quotient between numbers of trees in successive 2-inch d.b.h. classes. Advantages of the method are precision coupled with reasonable simplicity and speed of calculation.

*Leak, William B.
1963. **Delayed germination of white ash seeds under forest conditions.** Jour. Forestry 61: 768, 770, 772, illus.
Delayed germination may have important silvicultural implications. During a small study of the effects of partial cutting and seedbed treatment on seedling establishment, many white ash seeds remained dormant until the second growing season and a few until the third.

*Leak, William B.
1963. **Effects of seedbed, overstory, and understory on white ash regeneration in New Hampshire.** U. S. Forest Serv. Res. Paper NE-2, 13 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
In a small study using hand-sown plots, delayed germination of white ash until the second and third year after sowing was observed. Cuttings of 0, 20, and 40 percent had little effect upon seedling catch. Scari-

fication of the seedbed after sowing produced a much greater catch than pre-scarification or no seedbed treatment.

*Little, S.
1963. **Injector treatments for killing New Jersey and eastern Maryland hardwoods.** Northeast. Weed Control Conf. Proc. 17: 494-501.

Tree injectors were proving efficient in the South for killing undesirable hardwoods, but local information was needed as a basis for treatment recommendations in New Jersey and eastern Maryland. Recent trials indicate that an ester formulation of 80 pounds ahg. in oil is generally effective for the several species found in mixed stands while amines may be used with success in oak stands. Complete low frills and the application of at least 2.0 ml. of solution per cut are recommended.

Little, S.
1963. **Mistblower treatments in regenerating preferred species in the forests of New Jersey, eastern Maryland, and eastern Pennsylvania.** Northeast. Weed Control Conf. Proc. 17: 517-526.

A series of trials provided information on chemicals and concentrations suited to (1) the selective release of conifers and (2) treatment of advanced growth to favor both conifers and hardwoods in several common eastern types. Because of drift, these treatments must not be used near ornamentals or agricultural crops.

*Little, S., and J. J. Mohr.
1963. **Conditioning loblolly pine stands in eastern Maryland for regeneration.** U. S. Forest Serv. Res. Paper NE-9, 21 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

When pine stands are harvested on Maryland's Eastern Shore, hardwood understories tend to take over the area. Prescribed burning and shelterwood cutting, applied before the main harvest cutting, reduce the hardwood competition and should ensure a new stand of 85 to 90 percent pine. Such treatments should prove both economically and silviculturally desirable on the Eastern Shore.

*Little, S., and J. J. Mohr.
1963. **Five-year effects from row thinnings in loblolly pine plantations of eastern Maryland.** U. S. Forest Serv. Res. Paper NE-12, 15 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Although row thinning appeared to be a practical method for thinning loblolly pine plantations, information was first needed on the silvicutural effects. Four treatments were tried in a 17-year-old plantation: cutting every second, third, fourth, or fifth row. Considering both the response to treatment and the residual stocking in crop trees, the cutting of every third row is recommended.

McQuilkin, W. E.
1963. **Economic and scenic problems in maintenance of rights-of-way. In Pesticides—their use and effect.** N. Y. Joint Legis. Com. Natl. Resources Symposium Proc.: 100-110. Albany.

The primary objectives of chemical brush control on utility and high-

way rights-of-way are: (1) complete kill of objectionable plants; (2) preservation of desirable ground-cover species; and (3) minimum foliage browning or other damage to scenic values. Although they are more expensive to apply, selective basal-stem treatments with 2,4,5-T meet these objectives better than broadcast foliage treatments.

Pauley, S. S., A. G. Johnson, and F. S. Santamour, Jr.
1963. **Results of aspen screening tests: I. Seed sources of quaking aspen (*P. tremuloides* Michaux).** Univ. of Minn. Forestry Notes 136, 2 pp.

A screening test established during 1951-54 in eastern Massachusetts provided comparative data on 29 seed sources of quaking aspen. The results suggest that western and high-latitude sources of quaking aspen hold little promise for planting in eastern Massachusetts.

Pauley, S. S., A. G. Johnson, and F. S. Santamour, Jr.
1963. **Results of aspen screening tests: II. Seed sources of European aspen (*Populus tremula* Linnaeus).** Univ. Minn. Forestry Notes 137, 2 pp.

Comparisons of 12 seed sources of European aspen were provided by a screening test established in 1951-54 in Middlesex County, Mass. The results indicated that high-latitude sources of European aspen hold little promise for planting in the Northeast or Lake States whereas central and southern Euorpean sources may prove adaptable.

Pauley, S. S., A. G. Johnson, and F. S. Santamour, Jr.
1963. **Results of aspen screening tests: III. F_1 hybrid progenies of quaking X European aspen.** Univ. Minn. Forestry Notes 138, 2 pp.

The performance of 14 F_1 hybrids from controlled crosses of Massachusetts-source quaking aspen with various pollen sources of European aspen were compared up to an age of 10-13 years. The comparisons suggested that selected sources of European aspen from middle or southern latitudes, coupled with quaking aspen sources from east-central North America, should provide vigorous hybrids suited to planting in the Northeast, Lake States, and adjacent Canada.

Pauley, S. S., A. G. Johnson, and F. S. Santamour, Jr.
1963. **Results of aspen screening tests: IV. F_1 hybrid progenies including European, quaking, bigtooth, and Chinese aspen.** Univ. Minn. Forestry Notes 139, 2 pp.

Five F_1 progenies derived from controlled crosses among 4 species were compared up to an age of 10-13 years in eastern Massachusetts. On the basis of the results, the authors recommend that further crosses of *P. grandidentata* with *P. tremula* and *P. tremuloides* should be undertaken.

*Phillips, John J.
1963. **Advance reproduction under mature oak stands of the New Jersey Coastal Plain.** U. S. Forest Serv. Res. Note NE-4, 5 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

In the Coastal Plain, information was needed to substantiate the observation that regeneration success was related to soil moisture conditions. A survey revealed that shrub competition and the percentages of

desirable tree species varied considerably among wet, moist, and dry sites.

*Phillips, John J., and Marco L. Markley.
1963. **Site index of New Jersey sweetgum stands related to soil and water-table characteristics.** U. S. Forest Serv. Res. Paper NE-6, 25 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

A soil-factor equation for predicting site index of sweetgum was developed for mature soils of the New Jersey Coastal Plain. The important variables were percent of clay and percent of fine sand in the B_2 horizon, the difference in silt-plus-clay contents between the B_2 and A horizons, and the thickness of the B_2 horizon. Soil series classifications also had diagnostic value, but their value would probably be improved by mapping subsoil thickness and placing more emphasis on fine sand content rather than total sand.

Roberts, B. R., P. J. Kramer, and C. M. Carl, Jr.
1963. **Long-term effects of gibberellin on the growth of loblolly pine seedlings.** Forest Sci. 9: 202-205.

Most previous studies with gibberellin had dealt with short-term effects. A study that covered a period of about 1½ years indicated that 9-months treatment with 3 concentrations of gibberellin increased height growth but that the differences in height between treated and untreated seedings decreased after the treatments were discontinued. The root/shoot ratios of the treated seedlings were consistently lower than those of the untreated.

Santamour, Frank S., Jr.
1963. **Chromosome number in *Tsuga*.**
Univ. Pa. Morris Arboretum Bul. 14: 51.

The wide variety of forms in eastern hemlock and the rarity of polyploids among conifers prompted a cytological investigation to determine the extent of polyploidy among the available members of *Tsuga* at the Morris Arboretum. Chromosome counts of $n=12$ revealed that all species and forms examined were diploid.

Santamour, Frank S., Jr.
1963. **Cytological studies in the Theaceae.**
Univ. Pa. Morris Arboretum Bul. 14: 51-53, illus.

No cytological investigations of the native species of the Theaceae had been made. This study provided chromosome counts for the native species and some exotic species and also showed that *Gordonia* and *Franklinea* could be distinguished as separate genera on a cytological basis.

*Santamour, Frank S., Jr.
1963. **Thirteen-year growth of some green ash provenances in the Northeast.** U. S. Forest Serv. Res. Note NE-14, 5 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

The relative performances of various green ash provenances are of considerable practical importance because this species is one of the few hardwoods that is planted in appreciable numbers. This study indicated that green ash from southern sources is not well adapted to

western Massachusetts and that individual tree variation is at least as important as variation among provenances.

*Santamour, Frank S., Jr., Frank E. Cunningham, and Richard J. Peterson.
1963. **Variation in resistance of hard pines to mouse damage.** U. S. Forest Serv. Res. Note NE-5, 6 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

The preferences of mice for various tree species are inconsistent and poorly understood. Mouse damage in two plantations of exotic species and hybrids of hard pines revealed a definite difference among progenies. The hypothesis is advanced that resistance or susceptibility to mouse damage is related to the proportions of delta-3-carene and alpha-pinene.

Santamour, Frank S., Jr., and Harry C. Kettlewood.
1963. **The preparation of spruce and hemlock herbarium specimens.** Univ. Pa. Morris Arboretum Bul. 14: 15-17, illus.

Standard herbarium techniques are not suitable for preserving specimens of *Picea* and *Tsuga*. Impregnation of spruce and hemlock branches with a solution of water and a commercial formulation containing glycerine and a fungicide produced reasonably attractive and well-preserved specimens.

*Schreiner, Ernst J.
1963. **Selection and breeding in Christmas tree production.** Amer. Christmas Tree Growers' Jour. 7(1): 17, 50-52.

Because of the relatively short-term investments and high market values associated with Christmas tree production, reasonably high expenditures for selection, breeding, and other intensive cultural work seem warranted. The author suggests the use and evaluation of seedling seed orchards and grafted planting stock from superior trees; continued tests of promising races and ecotypes; and a long-term, cooperative breeding program.

Schreiner, Ernst J.
1963. **Some suggestions for plus-tree selection and seedling seed orchards.** Northeast. Forest Tree Improve. Conf. Proc. 10: 53-60.

Certain guidelines are needed to make plus-tree selection as efficient as possible. The author provides theoretical guides on the choice of plus trees, and discusses improvement objectives. Specific suggestions are given on the establishment of a white pine seedling seed orchard.

Schreiner, Ernst J.
1963. **Improvement of disease resistance in Populus.** United Nations FAO World Consult. on Forest Genet. and Tree Improve., Sect. 6a/2, 21 pp. Stockholm.

Although poplars rank high in susceptibility to pests, the genus offers excellent possibilities for rapid improvement in both disease and insect resistance. Past work on the breeding and selection of disease-resistant poplars has proceeded by empirical methods primarily. Maximum progress in the future on both disease and insect resistance will be achieved by interdisciplinary basic research.

*Sucoff, Edward.
1963. **Bud-pruning not beneficial for Virginia pine.**
Jour. Forestry 61: 37-39, illus.
Russian literature suggests that bud-pruning will result in excellent form and rapid growth at a feasible cost. Bud-pruning of Virginia pine coupled with thinning resulted in few knots; but it also reduced height and diameter growth and caused severe stem deformities. Bud-pruning is not recommended for Virginia pine.

*Tepper, Herbert B.
1963. **Leader growth of young pitch and shortleaf pines.**
Forest Sci. 9: 344-353, illus.
The morphological characteristics of the leader and the growth of its component parts had not previously been described for pitch and shortleaf pine. A detailed study showed, among other things, that winter buds are often multinodal, that elongation of the leader begins in the basal internode and moves toward the tip, and that each internode displays a sigmoid growth curve that achieves its peak rate after the internode below it.

*Trimble, George R., Jr.
1963. **Cull development under all-aged management of hardwood stands.** U. S. Forest Serv. Res. Paper NE-10, 10 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Upon initiation of management on a forest property, a question arises as to the size of the cull-removal job over a period of years. Records over a 10-year period on the Fernow Experimental Forest in West Virginia indicate that the development of new culls is remarkably slow in mountain hardwoods. Cull removal should be a minor task after one thorough initial treatment has been made.

*Trimble, George R., Jr.
1963. **Hybrid poplar grows poorly on acid spoil banks at high elevations in West Virginia.** U. S. Forest Serv. Res. Note NE-7, 4 pp., illus. Northeast. Forest Expt. Sta., Upper Darby Pa.
As part of a region-wide hybrid poplar study, 50 selected clones were planted in 1951-52 on acid, compact strip-mine spoils at an elevation of about 3,500 feet. Although growth and survival were noticeably better on a limed block than on several unlimed blocks, results of the study clearly demonstrated that hybrid poplars should not be used to revegetate such sites.

*Trimble, G. R., Jr., and Burley D. Fridley.
1963. **13 years of forestry research in West Virginia.**
U. S. Forest Serv. Res. Paper NE-5, 55 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
With the growing pressures upon the use of forest land, the need for integrated management information becomes imperative. This report reviews the program of research at Elkins, West Virginia, which stresses integrated studies of timber, water, and wildlife. Considerable progress is being made toward solving the practical forest-land use problems of the area.

*Trimble, George R., Jr., Carter B. Gibbs, and Carl R. Barr.
1963. **Truck roads and small forest products.** Northeast. Logger 11(12): 16-17, 40-41, 46-47, illus.
Because of a low profit margin, cordwood harvesting will probably continue to be done mainly in areas near truck roads built primarily for other purposes. More complete harvesting of the currently inaccessible sources of cordwood could come about through the development of a cheaper system of skidding cordwood or an increase in the unit value of small products.

*Trimble, George R., Jr., and Henry Clay Smith.
1963. **What happens to living cull trees left after heavy cutting in mixed hardwood stands?** U. S. Forest Serv. Res. Note NE-12, 6 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Results of a study in mixed Appalachian hardwoods indicate that large culls should be deadened at the time of logging because few will be destroyed in logging or will die soon afterward. On the other hand, it might be desirable to delay the treatment of small culls until 5 years after logging because a fair number will have died naturally by then and other small trees damaged in logging will have developed into culls that obviously should be removed.

*Trimble, G. R., Jr., and G. W. Wendel.
1963. **Cost of marking hardwood sawtimber in West Virginia.** U. S. Forest Serv. Res. Note NE-15, 4 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Tree marking is one of the most important operations in timber management. Data from an experimental management unit revealed that the costs of marking for a combination harvest and improvement cutting in mountain hardwoods were reasonably low—about $1.00 per 1,000 board feet.

*Wilson, Robert W., and William E. McQuilkin.
1963. **Silvical characteristics of eastern white pine.** U. S. Forest Serv. Res. Paper NE-13, 29 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
This paper outlines the silvics of eastern white pine—once the mainstay of the Northeast's timber economy—including habitat conditions, life history, enemies, reaction to competition, and racial variations.

Forest Fire

Banks, Wayne G.
1963. **A table for checking the reasonableness of entries on fire report forms.** U. S. Forest Serv. Fire Control Notes 24: 76-80.
Discrepancies or impossible combinations often occur on fire report forms; so a table was developed to show probable acreage burned in relation to fire-perimeter increase and elapsed time. The table will be helpful in detecting large errors on fire report forms.

Burke, Hubert D.
1963-64. **Careers in outdoor recreation.**
N. Y. Conservationist 18 (3): 14-15, 35.
The growing demand for outdoor recreation is providing opportunities for a wide variety of careers in unskilled, skilled, semi-professional, and professional fields. These opportunities offer a bright future for those who are willing to prepare themselves.

Burke, Hubert D.
1963. **Forest recreation research.**
Great Lakes Park Training Inst. Proc. 7: 79-85.
As an aid to those who make legislative or administrative decisions, the author outlines the scope of forest-recreation research and some of the available sources of information. Four planning or operating aspects are considered: regional planning, recreation land selection, area development, and day-to-day operation.

*Burke, Hubert D. and Francis M. Rushmore.
1963. **A planning guide for outdoor recreation in Washington County, Maine.** Univ. Maine Coop. Ext. Serv. Bul. 500, 72 pp., illus.
Outdoor recreation could make important contributions to the economy of Washington County. The recreation resources and opportunities in the county are described, together with general suggestions for an organized approach to the development of a recreation industry. This paper provides the basis for a local action program.

*LaPage, Wilbur F.
1963. **Some sociological aspects of forest recreation.**
Jour. Forestry 61: 32-36.
In a philosophical treatment of some problems in forest recreation management and research, the author points to the need for a measure of recreation productivity, perhaps based upon consumer satisfaction.

*Wagar, J. Alan.
1963. **Relationships between visitor characteristics and recreation activities on two national forest areas.** U. S. Forest Serv. Res. Paper NE-7, 19 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
A study on the Stuart Recreation Area in West Virginia and the Twin Lakes Recreation Area in Pennsylvania provided information on the relationships of various economic and sociological user-characteristics to user preferences and activities. Some relationships were common to both areas; thus it is possible that further research may develop general visitor-use patterns that will apply outside the two study areas.

Wagar, J. Alan.
1963. **What people want in forest recreation.**
W. Va. Conserv. 27(5): 9-12, illus.
Visitor participation in various activities at the Stuart Recreation Area in West Virginia was related to distance from home, occupation, age, income, education, health, marital status, and sex. Additional informa-

tion of this type from other recreation areas will enable better planning for future recreation needs.

Wagar, J. Alan.
1963. **What people want in forest recreation.** Pa. Forests 43(1): 6-7, illus.
The participation in various activities of visitors to the Twin Lakes Recreation Area in Pennsylvania was related to distance from home, occupation, age, income, marital status, and sex. The results provide a basis for continued research that should lead to more efficient planning.

Wagar, J. Alan.
1963. **Convention (sic) stacks—how they rid pit toilets of odors.** Parks & Recreation 46: 330-331, illus.
To meet one of the common problems in outdoor recreation areas, a flame-actuated convection stack was developed to provide a safe and inexpensive way to eliminate foul smells from pit toilets.

Wildlife Habitat

*Shafer, Elwood L.
1963. **The twig-count method for measuring hardwood deer browse.** Jour. Wildlife Mangt. 27: 428-437, illus.
The coordination of deer and timber management in the Northeast had been seriously hampered by the lack of a feasible method for measuring browse production and utilization. The twig-count method proved as accurate as the laborious and destructive clip-and-weight method and nearly as rapid as the rather subjective weight-estimation method.

Watershed Management

*Eschner, Arthur R., and Jack Larmoyeux.
1963. **Logging and trout: four experimental forest practices and their effect on water quality.** Progressive Fish-Culturist 25: 59-67, illus.
Clearcutting a West Virginia watershed resulted in significantly higher maximum stream temperatures, above those generally tolerated by brook trout. The increase in dissolved solids noted was not great enough to affect stocking.

*Eschner, A. R., and D. R. Satterlund.
1963. **Snow deposition and melt under different vegetative covers in central New York.** U. S. Forest Serv. Res. Note NE-13, 5 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Snow measurements in 5 cover types in the Allegheny Plateau suggest that if a warm period comes early in the spring, forest snow melt contributes less and slower runoff than open areas. When warm weather comes late, with an appreciable snowpack only in the forest, the reverse should be true. A mixture of forest cover and open area may provide the best land-use control of snowmelt runoff.

*Felton, Paul M., and Howard W. Lull.
1963. **Suburban hydrology can improve watershed conditions.** Public Works 94 (1): 93-94, illus.
Infiltration measurements in woods, fields, and lawns in Philadelphia's suburban Wissahickon watershed showed that relative infiltration under present land-use is about one-half of what it was for forested conditions. Methods by which suburbanites may increase infiltration are discussed.

*Fletcher, Peter W., and Howard W. Lull.
1963. **Soil-moisture depletion by a hardwood forest during drought years.** Soil Sci. Soc. Amer. Proc. 27 (1): 94-98, illus.
Daily soil-moisture measurements were taken in a mixed oak-hickory stand in pairs of plots that were bare, had litter only, trees only, and trees and litter (no treatment). Soil-moisture regimens are interpreted in respect to tree mortality due to drought.

*Hart, George.
1963. **Snow and frost conditions in New Hampshire, under hardwoods and pines and in the open.** Jour. Forestry 61: 287-289, illus.
White pine and red pine plantations were comparable in snow depth, but a hardwood stand had a snow depth similar to that in an open field. Differences were attributed mainly to canopy density. Order of snow disappearance was: (1) open field, (2) hardwoods, (3) red pine, (4) white pine. Melt rates were 0.10, 0.05, and 0.04 inches per day for hardwoods, white pine, and red pine respectively.

*Hart, George, and Howard W. Lull.
1963. **Some relationships among air, snow, and soil temperatures and soil frost.** U. S. Forest Serv. Res. Note NE-3, 4 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Winter temperatures of air, snow, and soil measured on a snow-covered plot and bare plots near Laconia, N. H., showed an increase in temperature and a reduction in its temporal variation going from air to snow to soil. Results are interpreted in respect to frost formation.

*Leonard, Raymond E., and Kenneth G. Reinhart.
1963. **Some observations on precipitation measurement on forested experimental watersheds.** U. S. Forest Serv. Res. Note NE-6, 4 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Exposure of precipitation gages by clearcutting a West Virginia watershed reduced annual catch by a little less than 3 percent and winter catch from 3 to 7 percent. Tilting precipitation gages did not give the increased catch that had been reported in the West. Uses of tilted and vertical gages are discussed.

*Lull, Howard W.
1963. **Forest influences research by questionnaire.** Jour. Forestry 61: 778-782.
Interest in forest influences on streamflow and climate, particularly around the turn of the century—and a paucity of information on this subject—led to polls by various states to collect information by ques-

tionnaires. The answers illustrate the certainty with which opposing viewpoints were held.

*Reigner, Irvin C.
1963. **A vinyl-lined weir for small watershed studies.** Jour. Forestry 61: 297-298, illus.
An inexpensive weir to gage small streams was built of wood and lined with a sheet of vinyl film. The cost was about $850 and the weir is expected to last 5 to 10 years without repair. Construction details are presented.

Reinhart, Kenneth G.
1963. **Efficient logging protects water quality.** South. Lumberman 206 (2567): 39, 42.
Results from the Fernow watershed in West Virginia showed that proper planning and construction of the skidroad system can minimize the area required for bulldozed skidroads. Reduction of the exposed soil surface reduces the sedimentation hazard and protects water quality.

*Reinhart, K. G., A. R. Eschner, and G. R. Trimble, Jr.
1963. **Effect on streamflow of four forest practices in the mountains of West Virginia.** U. S. Forest Serv. Res. Paper NE-1, 79 pp., illus. Northeast Forest Expt. Sta., Upper Darby, Pa.
Four intensities of forest management, ranging from commercial clearcutting to an intensive selection cutting, were applied on calibrated watersheds. Increases in annual flow ranged from 5.1 to 0.3 area-inches in relation to volume cut. Road location and drainage affected water quality.

Satterlund, Donald R., and Arthur R. Eschner.
1963. **Forest watershed management in New York.** N. Y. State Univ. Coll. Forestry, Syracuse. 32 pp., illus.
Forest-watershed management problems of the various water-resource regions are noted and their relative importance is assessed. In view of these problems and the fact that one-half of the State's land is forested, research is needed on the relationship of forest conditions to quality, timing, and quantity of streamflow.

Trimble, G. R., Jr.
1963. **Watershed management research, N. E. For. Expt. Sta.** Amer. Pulpwood Assoc. Tech. Paper 63-P-3. 6 pp.
Forest watershed research in Appalachia is described and some results of studies on water yield and water quality are given.

*Trimble, George R., Jr., K. G. Reinhart, and Henry H. Webster.
1963. **Cutting the forest to increase water yields.** Jour. Forestry 61: 635-640.
From watershed research results in West Virginia, the estimated cost of increasing water yields by clearcutting, based on loss in timber income and cost of treatment, is about $0.04 per 1,000 gallons. Effects of cutting on peak flows and water quality are also discussed.

*Campbell, Robert W.
1963. **Some ichneumonid-sarcophagid interactions in the gypsy moth *Porthetria dispar (L.) (Lepidoptera: Lymantriidae).*** Canad. Ent. 95: 337-345.
Observations of four ichneumonid species attacking the gypsy moth show that all sting and kill more hosts than can be discerned by rearing the parasite progeny from sample collections of host larvae and pupae. Sarcophagids found in gypsy moth pupae are apparently only scavengers, entering the host through openings made by ichneumonids and predators. When predation is negligible, the proportion of pupae containing sarcophagids indicates the true effect of ichneumonids on the gypsy moth population.

*Campbell, Robert W.
1963. **The role of disease and desiccation in the population dynamics of the gypsy moth, *Porthetria dispar (L.) (Lepidoptera: Lymantriidae).*** Canad. Ent. 95: 426-434.
The incidence of disease and a condition termed desiccation is shown to be closely related to density of the insect. Both factors are important in reducing gypsy moth populations.

*Campbell, Robert W.
1963. **Some factors that distort the sex ratio of the gypsy moth, *Porthetria dispar (L.) (Lepidoptera: Lymantriidae).*** Canad. Ent. 95: 465-474.
Disease, desiccation, and ichneumonid parasites kill the sexes of the gypsy moth in different proportions, resulting in sex ratios ranging from 2 to 80 percent females among adults. It is suggested that the population consequences of any mortality factor be evaluated in terms of the more critical sex (female) destroyed.

*Cosenza, Benjamin J., Edwin A. Boger, Normand R. Dubois, and Franklin B. Lewis.
1963. **A simple device for dehairing insect egg masses.** U. S. Forest Serv. Res. Note NE-1, 4 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Describes a device utilizing air agitation to remove the hairs and other debris from egg masses of insects such as the gypsy moth without injuring the individual eggs.

*Levesque, Gilbert.
1963. **A technique for sexing fully developed embryos and early-instar larvae of the gypsy moth.** U. S. Forest Serv. Res. Note NE-2, 3 pp., illus. Northeast. Forest Expt. Sta., Upper Darby Pa.
Describes a differential staining technique for whole-mounts that reveals the gonadal tissues of very young gypsy moth larvae well enough to separate the sexes.

*Somes, H. A., and T. McIntyre.
1963. **Tip-moth control fails to improve height of planted loblolly**

pines in a Maryland study. U. S. Forest Res. Note NE-16, 3 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Three spray treatments with DDT prevented most of the injury by the first annual brood of tip-moth larvae but had no apparent effect on later broods, and no effect on height growth, which is retarded by tip-moth damage.

*Waters, William E.

1963. **Some new approaches to the insect problem.** Soc. Amer. Foresters Proc. 1962: 36-40.

Cites the need for new and better analytical techniques for evaluating insect infestations and gives two mathematical models as examples. Suggests that insect control in artificially regenerated stands be conceived and conducted on a program rather than individual project basis. Describes new biotic and chemical means of controlling destructive insects.

Forest Diseases

Brandt, Robert W.

1963. **What to do about ash dieback.** Forest World 2 (2): 31-33.

A general description of the dieback condition affecting ash trees in the Northeast and causing grave concern among foresters and forest industries. Describes history, distribution, and symptoms of the disease. Recommends that dying trees be salvaged wherever feasible.

Davidson, A. G., and M. E. Fowler.

1963. **Scab and black canker of willow.** ***In*** **Important forest diseases of mutual concern to member countries of the North American Forestry Commission:** 58-59. N. Amer. Forestry Comn., FAO.

Outlines distribution of the disease in the United States and Canada. All species of willow are susceptible, and damage is considerable on shade and ornamental trees. Loss in forest stands is slight because of the low value of willows as forest trees.

Diller, Jesse D.

1963. **Preliminary results from blight inoculations on 5-year-old American chestnut grafts.** North. Nut Growers Assoc. Ann. Rpt. 53: 22-23.

Despite the fact that eight 5-year-old American chestnut grafts on two 15-year-old Chinese chestnut and two 67-year-old Japanese chestnut trees remained blight-free for a 5-year period, all of the grafts proved to be susceptible when subjected to artificial inoculation at the beginning of the sixth year.

Diller, Jesse D.

1963. **Differentiation of three Atropellis species, based on gross cultural characteristics.** (Abstract.) Rev. Appl. Mycol. 42: 730.

Three species of Atropellis grown on malt agar in petri dishes made their maximum growth at 20°C. One was completely inhibited at 25°C., another at 30°C., but the third still exhibited slight growth at 30°C.

Diller, Jesse D., and E. James Koch.

1963. **Trichlorobenzene as a soil toxicant against four wood-decaying soil fungi.** (Abstract.) Phytopathology 53: 745.

The wood-destroying abilities of four fungi *(Poria incrassata, P. vaillantii, Merulius lacrymans,* and *M. americanus)* were gaged by measuring weight loss of test blocks of wood. On plots treated with trichlorobenzene, test blocks showed less than 3.4 percent weight loss versus 32.5 percent weight loss on check plots.

*Fowler, Marvin E.

1963. **A guide to forest disease research in the Northeast.** U. S. Forest Serv. Northeast. Forest Expt. Sta., 45 pp. Upper Darby, Pa.

Describes and analyzes the forest disease problems in the Northeastern United States, and assigns priority ratings to disease problem areas and studies. Discusses desired scope and depth of research needed for 89 disease problems defined.

Fowler, Marvin E.

1962. **Fomes annosus in northeastern United States.** IUFRO Conf. and Study Tour on Fomes annosus, Sect. 24, Forest Protection: 20-22. Firenze.

Collections of *Fomes annosus* more than 70 years ago, and general distribution of the fungus on conifers throughout the Northeast, are cited as evidence that the fungus probably is indigenous in the region. Greatest damage from the root rot caused by the fungus is in coniferous plantations after thinning operations.

Fowler, Marvin E.

1963. **Forest insect and disease research—N. E. For. Exp. Sta.** Amer. Pulpwood Assoc. Tech. Paper 63-P-4. 4 pp.

Outlines the major forest pest problems and the research program now under way by the Northeastern Station.

Fowler, Marvin E.

1963 **Fir tip blight.** ***In*** **Internationally dangerous forest tree diseases.** U. S. Dept. Agr. Misc. Pub. 939: 109-110.

A brief description of the blight caused by *Rehmiellopsis balsameae* Waterman, which affects the needles of several species of fir in the northeastern United States. Though severe infections repeated for several years may kill small trees, the disease causes relatively little damage to forest trees; but it may be very damaging and disfiguring to ornamentals.

*Houston, David R.

1963. **Inoculations of oaks with *Urnula craterium* (Schw.) Fr. produces cankers identical to *Strumella* cankers.** U. S. Dept. Agr. Plant Dis. Rptr. 47: 867-869.

Describes previously unpublished results of inoculation trials with *Urnula craterium* and *Strumella coryneoidea.* The development of identical cankers provides additional strong evidence that *Urnula* is the perfect stage of *Strumella.*

*Shigo, Alex L.
1963. **Beech bark disease.**
U. S. Dept. Agr. Forest Pest Leaflet 75. 8 pp., illus.
This disease, which complicates the growing of large high-quality beech trees, is attributed to an insect-fungus association in which the fungus *(Nectria coccinea* var. *faginata)* invades the tree through minute feeding wounds made by a scale insect *(Cryptococcus fagi)*. Describes the fungus, the insect, history and distribution of the disease, symptoms and course of the disease, damage done, and controls.

*Shigo, Alex L.
1963. **Beech bark disease.**
N. H. Forest Notes 78: 3-6, illus.
A nontechnical description of the disease caused by the insect *Cryptococcus fagi* and the fungus *Nectria coccinea* var. *faginata,* which is causing the death of many beech trees in the Northeast. See also above.

*Shigo, Alex L.
1963. **Fungi associated with the discoloration around rot columns caused by *Fomes igniarius.*** U. S. Dept. Agr. Plant Dis. Rptr. 47: 820-823, illus.
More than 2,400 isolations were made from the discolored areas surrounding rot columns caused by *Fomes igniarius* in 59 living trees; and bacteria and nonhymenomycetes as well as *F. igniarius* were isolated from almost every sample. The close association of these organisms suggests that all are important in the events leading to cell destruction in living trees.

*Shigo, Alex L.
1963. **Ring shake associated with sapsucker injury.**
U. S. Forest Serv. Res. Paper NE-8, 10 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.
Dissection of live hemlock and hardwood trees revealed evidence of old injuries caused by the yellow-bellied sapsucker *(Sphyrapicus varius varius* L.) and indicated a direct association between ring shake and feeding wounds caused by this bird.

Shigo, Alex L.
1963. **Relation of branch stubs to forest disease.**
N. H. Forest Notes 79: 4-7, illus.
A brief nontechnical account of the relation of branch stubs to canker diseases, decays and discolorations, and other diseases.

Shigo, Alex L., and G. L. Stone.
1963. **Beech bark disease. *In* Important forest diseases of mutual concern to member countries of the North American Forestry Commission:** 40-42. N. Amer. Forestry Comn., FAO.
Brief description of this disease—in which a fungus *(Nectria coccinea* var. *faginata)* and a scale insect *(Cryptococcus fagi)* are associated — which has become epidemic on American beech in the Northeast and is steadily spreading south and west. Discusses possible control measures and defines problems requiring further research.

*Shigo, Alex L., and George Yelenosky.
1963. **Fungus and insect injury to yellow birch seeds and seedlings.** U. S. Forest Serv. Res. Paper NE-11, 11 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Preliminary studies indicated that a fungus *(Coniothyrium* sp.), which apparently is on and in the seed before it falls, causes considerable injury to yellow birch seeds and seedlings. In the course of pathological studies, a weevil *(Apion walshii)* was found in many cones and had destroyed many seeds.

Forest Economics

*Webster, Henry H.
1963. **Timber management and economic analysis: a case study.** U. S. Forest Serv. Res. Paper NE-14, 26 pp., illus. Northeast. Expt. Sta., Upper Darby, Pa.

An economic analysis of timber-production possibilities in Elk State Forest in north-central Pennsylvania. Analysis proved efficient for ranking management opportunities and for setting priorities within a given budget, but proved of little use in determining how large the budget should be.

Webster, Henry H.
1963. **Research in the economics of industrial development in the Appalachian area.** Amer. Pulpwood Assoc. Tech. Papers October 1963: 8-10, illus. (APA Tech. Paper 63-5 (8.3).)

Plant-location decisions for the lumber, particle-board, woodpulp and furniture industries in the Northeast are described. Differences in the decision-making process between large and small plants and among the four industries are discussed.

*Webster, Henry H., and Perry R. Hagenstein.
1963. **Economic analysis of watershed management decisions—what sort of guides for land managers?** Jour. Forestry 61: 631-634.

Land managers are usually confronted with one of three types of economic decisions: to achieve fixed results at least cost; to achieve maximum results from a fixed expenditure; or to select courses of action that promise additional returns greater than the associated additional cost. Because of problems in measuring value response of watershed-management decisions, research in the economics of watershed management might best be concentrated on the first two types of decisions.

*Webster, Henry H., Robert J. Marty, and Richard A. Skok.
1963. **Forestry practice, biological research, and economic analysis.** Jour. Forestry 61: 754-759.

The synthesis of biological and economic information in a framework for analyzing forestry decisions is discussed in light of particular institutional situations and resource restraints. It is concluded that close cooperation between biological and economic researchers is essential for producing useful information.

*Whitmore, Roy A., Jr., Perry R. Hagenstein, William H. Reid, and Donald E. Nelson.

1963. **Marketing of lumber in the Northeast. Phase II. Lumber purchases by wood products manufacturers.** Vt. Agr. Expt. Sta. Bul. 635, 39 pp., illus.

The flow of lumber in the Northeast from sawmills to wood-products manufacturers is described. Lumber, lumber sources, and marketing practices are described; and lumber-purchasing problems encountered by lumber buyers are discussed.

Forest Survey

*Bickford, C. Allen.

1963. **More on sampling design.** Jour. Forestry 61: 142.

A comment on Shiue-John, *A proposed sampling design for extensive forest inventory: double systematic sampling for regression with multiple random starts* (Jour. Forestry 60: 607-610). Calculation of sample size to meet a prescribed accuracy at least cost is added. This makes it possible to compare relevant costs under various design alternatives such as simple random sampling, systematic sampling with random starts, and stratified double sampling.

*Bickford, C. Allen, Carl E. Mayer, and Kenneth D. Ware.

1963. **An efficient sampling design for forest inventory: The Northeastern forest resurvey.** Jour. Forestry 61: 826-833, illus.

The sampling design was developed at the Northeastern Station to provide required data to meet a present standard of accuracy at least cost for the resurvey of our 12 states. This design includes stratified double sampling at the first inventory followed by sampling with partial replacement at the second. Formulas are presented for estimating total volumes and areas and their sampling errors, and for calculating numbers of plots to establish and remeasure to meet an accuracy goal.

*Ferguson, Roland H., and Victor S. Jensen.

1963. **The timber resources of New Hampshire.** U. S. Forest Serv. Resource Rpt. NE-1, 46 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

A report on a resurvey 12 years after the initial forest survey made by the U. S. Forest Service, presenting statistical findings on forest-land area and timber volumes, and describing important changes and trends in the timber resource and the use of it by wood-using industries. Annual timber growth is compared with annual timber harvest.

Products Marketing

Cuppett, Donald G.

1963. **Program of research at the forest products marketing laboratory.** Amer. Pulpwood Assoc. Tech. Papers October 1963: 11-12. (APA Tech. Paper 63-7: (5.3).)

Describes the organization of this new laboratory at Princeton, W. Va.,

and outlines the research program designed to improve the marketing of primary wood products, primary wood manufactures, wood for construction, and secondary wood manufactures.

Hagenstein, Perry R.

1963. **Forest products marketing research in the Northeast: where are we heading?** Amer. Pulpwood Assoc. Tech. Papers October 1963: 10-11. (APA Tech. Paper 63-6: (8-1).)

Marketing research is directed at increasing the efficiency of marketing, at expanding the markets for forest products, and at analyzing production and consumption trends in order to project likely conditions under which timber will be used in the future. Marketing research directed at different objectives requires different research techniques.

*Northeastern Forest Experiment Station.

1963. **The forest products marketing laboratory at Princeton, West Virginia.** U. S. Forest Serv. Northeast. Forest Expt. Sta. 8 pp., illus.

Describes the physical facilities and the research program of the new research laboratory established in West Virginia to find ways in which the forest resources and the forest industries can make a greater contribution to the economic welfare of the Appalachian Region.

Utilization Improvement

*Behr, E. A.

1963. **Preservative treatment of beech.**

Northeast. Tech. Comm. Util. Beech and U. S. Forest Serv. Northeast. Forest Expt. Sta. Beech Util. Ser. 21, 16 pp. Upper Darby, Pa.

Beech lumber needs the addition of a preservative if it is to be used in contact with soil or in other exposed situations. Creosote, 60/40 creosote-petroleum, and zinc chloride are three preservatives that have been used with reasonable success.

*Frank, Robert M.

1963. **A survey of sawmill residues and lumber as raw materials for wood-using industries in West Virginia.** U. S. Forest Serv. Res. Paper NE-3, 20 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Volumes of sawmill residues and lumber available in 1960 for development of wood-using industries were estimated for four selected areas. Volumes are presented by species, availability, and quality classes where relevant.

Jorgensen, Richard N.

1963. **Research and utilization.**

North. Logger 12 (5): 18, 39.

Explains the objectives of the utilization-improvement project of the Northeastern Forest Experiment Station, reviewing briefly the types of research in progress at the universities of the Northeast and how this work will effect logging operations. Recommends a committee within the Northeastern Loggers Association to stimulate and sponsor research in logging.

*Ostrander, M. D., and others.

1963. **A guide to hardwood log grading.**
U. S. Forest Serv. Northeast. Forest Expt. Sta., Upper Darby, Pa., 50 pp., illus.

A handbook developed primarily as a teaching aid and field reference in grading hardwood logs. Outlines basic principles and gives detailed practical applications in grading logs and cruising timber. Includes standards for various use classes.

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